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PARADISE IRRIGATION DISTRICT

6332 Clark Road, Paradise CA 95969 | Phone (530)877-4971 | Fax (530)876-0483

"Paradise Irrigation District (PID) is dedicated to the business of producing and delivering a safe, dependable supply of quality water in an efficient, cost effective manner with service that meets or exceeds the expectation of our customers."

Please consider how this agenda item relates to our mission.

TO: Board of Directors

FROM: Kevin Phillips, Interim District Manager

DATE: October 13, 2017

RE: Spillway Investigation

At its July 19, 2017 meeting the Board of Directors approved the proposal by Genterra Consultants, Inc. for the development of the Phase I Spillway Condition Assessment Work Plans. The work plans are now complete and they have been reviewed and approved by DWR Division of Safety of Dams.

Upon completion of development of the Work Plans, District staff asked Genterra to prepare a proposal for implementation of the Work Plans. Genterra has submitted a draft proposal and cost estimate. The costs for Magalia Dam and Paradise Dam are $140,473 and $159,671, respectively. The total not-to-exceed cost for Phase I implementation is $300,144.

The work plans include detailed review of existing documentation, field evaluations and non-destructive testing, geologic reconnaissance and surficial mapping, geophysical surveys, and engineering evaluations of structural integrity and stability. Upon completion of these tasks, Genterra will prepare a Phase I condition assessment report for each dam. If issues are encountered in the Phase I work that require additional investigation (for example through the use of drilling, coring, or other destructive methods), Genterra will also prepare the Phase II Work Plan as part of their scope of work for the Phase I implementation.

The proposal and cost estimate are in draft form. Genterra understands the financial challenges that the District faces and they have addressed this in the proposal by calculating charges based on their 2015 fee schedule and by using fees for several personnel that reflect a reduced classification and lower billing rate. Genterra has indicated a willingness to consider adjustments to the scope of work, etc. as well. District staff requests Board review and provide direction on possible adjustments to the work plan implementation.

Time is of the essence. Weather will begin to have an impact and limit access to the spillways to conduct inspections and geophysical surveys. This could have the effect of delaying the work for 6 months or more. Delays could also increase costs due to the pending commitments of the geophysics subcontractor. A timely decision on work plan implementation is likely to improve the District's chance of a successful outcome.

The following is requested:

"Accept the proposal for professional engineering services from Genterra Consultants, Inc. for implementation of the Phase I Spillway Condition Assessment Work Plans for Paradise Dam and Magalia Dam, for a not-to-exceed amount of $300,144, and direct the Interim District Manager to execute the professional services contract, or provide direction to staff for negotiating changes to the proposal."

October 9, 2017 Proposal No. P2335-PID_PhISpillwayCondAssess

Mr. Neil Essila
Paradise Irrigation District
6332 Clark Road
Paradise, CA 95969-4146

DRAFT FOR REVIEW

Subject: Proposal for Implementation of Phase I Spillway Condition Assessments
Magalia Dam, No. 73 and Paradise Dam, No. 73-2, Butte County, California

Gentlemen,

In response to the Request for Proposal (RFP) sent to me by Email on October 3, 2017, GENTERRA Consultants, Inc. (GENTERRA) is pleased to submit this proposal to the Paradise Irrigation District (PID) to implement the Phase I condition assessments of the spillways at Magalia Dam and at Paradise Dam in accordance with GENTERRA's Phase I Work Plans approved by the State Division of Safety of Dams (DSOD). The work plans for each dam were presented in a document entitled "Summary of Known Issues and Phase I Work Plan for Spillway Condition Assessment", dated September 25, 2017, which had been prepared by GENTERRA, reviewed by PID, revised based on comments received from the DSOD, and approved in a letter attachment to an Email from DSOD to PID and GENTERRA on October 3, 2017. The Phase I Work Plans present the scope of detailed condition assessments of each of the two spillways that includes evaluations of the concrete linings, the existing drainage systems, and any potential for slab undermining and hydraulic jacking at each dam.

As the designated Principal-In-Charge and Project Manager, I will commit the resources needed in a timely, responsive and cost-effective manner. I have full authority for contracts and to make decisions and am authorized to make representations for the proposed GENTERRA team. Please contact me or Dr. Soma Balachandran with any questions at (949) 753-8766. You may also contact me at my Email joekul@genterra.com, or Soma at somabala@genterra.com.

Sincerely,
GENTERRA Consultants, Inc.

Joseph J. Kulikowski, P.E., G.E.
President and Senior Principal Engineer

Reference Document No. 1. "Summary of Known Issues and Phase I Work Plan for Spillway Condition Assessment for Magalia Dam" by GENTERRA, dated September 25, 2017

Reference Document No. 2. "Summary of Known Issues and Phase I Work Plan for Spillway Condition Assessment for Paradise Dam", by GENTERRA, dated September 25, 2017

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SECTION A. INTRODUCTION, BACKGROUND AND PURPOSE

A.1 Introduction

This proposal is being submitted by GENTERRA Consultants, Inc. (GENTERRA) to the Paradise Irrigation District (PID) in response to the Email from Neil Essila dated October 3, 2017, requesting a proposal to implement the approved Phase I work plans for detailed condition assessments of the spillways at Magalia Dam and at Paradise Dam to comply with the requirements of the State Division of Safety of Dams (DSOD). The proposed work will be done in accordance with GENTERRA's Phase I Work Plans approved by the DSOD, which are presented in a document for each dam entitled "Summary of Known Issues and Phase I Work Plan for Spillway Condition Assessment", dated September 25, 2017. That document had been prepared by GENTERRA, reviewed by PID, revised based on comments received from the DSOD, and approved in a letter attachment to an Email from DSOD to PID and GENTERRA on October 3, 2017. The Phase I Work Plans present the scope of a detailed condition assessment of each of the two spillways that would include evaluations of the concrete linings, the existing drainage systems, and any potential for slab undermining and hydraulic jacking at each dam.

The documents entitled ***"Summary of Known Issues and Phase I Work Plan for Spillway Condition Assessment for Magalia Dam" and "Summary of Known Issues and Phase I Work Plan for Spillway Condition Assessment for Paradise Dam"***, both prepared by GENTERRA and dated September 25, 2017, are incorporated by reference into this proposal. The Section headings in each of those documents are as follows:

Section 1: Introduction, Background and Purpose
Section 2: Summary of Work Plan Development Process
Section 3: Known Issues of Concern at Each of the Two Spillways
Section 4: Technical Comments Based on Initial Review of Available Information
Section 5: Phase I Work Plan
Section 6: Phase II Spillway Condition Assessment (If Required)
Section 7: Review and Coordination

The figures and the Attachments A, B, C and D for each of the two documents are also incorporated into this proposal.

A.2 Description of Magalia Dam and Spillway

On the list of jurisdictional dams maintained by the DSOD, Magalia Dam is listed as Dam Number 73-000. On the National Dam Inventory list, it is designated as Number CA00296.

Magalia Dam and Reservoir are located along Little Butte Creek, north of the Town of Paradise in Butte County, California. The reservoir is used by the PID for the storage of untreated water. As needed, the stored water is withdrawn from the reservoir, treated at the water treatment plant located just downstream of the dam, and distributed to the public as potable water. At the elevation of the spillway crest, which is 2225.8 feet above mean sea level, the reservoir has a storage capacity of 2,574 acre-feet. The freeboard (height from spillway crest elevation to dam crest elevation) is 13.7 feet. Since 1997, the water level in the reservoir has been restricted to a maximum elevation of 2200 feet by the DSOD because of concern about the potential for instability of the upstream slope of the dam under seismic loading conditions.

Magalia Dam is 103 feet high and has a crest length of 850 feet. It is a hydraulic-fill embankment dam built during 1917-1918 by sluicing materials from an adjacent quarry and depositing the slurry into the embankment to construct the dam. Compaction of the embankment materials was not performed. The dam consists of two embankments, separated by a rocky knoll. The main dam is located to the right (west) of the knoll, and the smaller saddle dam is to the left (east) of the knoll. The left and right designations are as viewed looking downstream. The upstream face of the main dam has a slope of approximately 2.7:1 (horizontal to vertical), whereas the upstream face of the saddle dam has a steeper slope, approximately 2.4:1. The slope of the downstream faces of both the main dam and the saddle dam are approximately 2:1. A gravel and asphalt-paved road forms a sloping bench across the downstream face of the dam.

In 1965, a toe drain and ballast fill were placed along the downstream toe, and the dam crest was raised two feet to an Elevation of 2240 feet. In 1975, new compacted fill was placed onto the downstream face of the dam to achieve a crest width of 50 feet, to accommodate the construction of the Skyway on the dam crest. In 1976, the outlet works were replaced with a 67-foot high intake tower connected to a 48-inch diameter steel outlet pipe, which is housed within a nine-foot-diameter reinforced concrete-lined tunnel which runs through the knoll located between the main dam and the saddle dam, with a single 30-inch-diameter valve which controls the outlet gate.

The concrete spillway inlet and channel are located on the left (east) side of the dam. The spillway is 70 feet wide at the crest, and the concrete-lined portion of the spillway channel is approximately 90 feet long. The spillway channel continues downstream as an unlined bedrock channel. Vegetation has been observed growing in the channel downstream of the spillway, and

GENTERRA has recommended that PID consider cutting and removing the vegetation so that it will not cause any tailwater concerns while heavy flows occur in the spillway channel.

We have observed that the spillway at Magalia Dam is severely cracked. Also, recent DSOD inspection reports have stated that they see the need to clear the spillway channel from the Highway bridge to Weir No. 1 by November 2017. Other conditions of concern related to the spillway by DSOD were discussed at the DSOD meeting on July 6, 2017 and will be incorporated into the work plan. One major issue is the questionable stability of the right spillway wall during flows in the spillway.

A.3 Description of Paradise Dam and Spillway

On the list of jurisdictional dams maintained by the DSOD, Paradise Dam is listed as Dam Number 73-002. On the National Dam Inventory list, it is designated as Number CA00297.

Paradise Dam and Reservoir are located on Little Butte Creek, north of the Town of Paradise in Butte County, California. The reservoir is used by PID for the storage of untreated water. As desired, the stored water is released from the reservoir and flows down Little Butte Creek to the diversion dam that had been constructed as part of the construction of the Magalia Bypass Pipeline in 2007. From that point, the water is piped downstream to the water treatment plant. Any water that overflows the diversion dam flows downstream into Magalia Reservoir. Paradise Reservoir has a storage capacity of 11,500 acre-feet.

Paradise Dam is 175 feet high and has a crest length of 975 feet. It is a zoned earthfill embankment dam consisting of an impervious core, a semi-pervious upstream zone, and a semi-pervious downstream zone. A chimney drain and a blanket drain composed of gravel drain materials and sand filter materials exist within the downstream zone of the dam. There is a layer of riprap over the upstream face of the dam. It was built in 1957, and then enlarged during 1976-1977 by increasing its height by 26.5 feet.

The outlet works consist of an inclined intake and five manually-operated slide gates. The outlet conduit, located near the right abutment, is 885 feet long and has a diameter of 42 inches. Flow through the outlet conduit is controlled by a 30-inch plug valve at its downstream end.

The upstream face of the dam has a variable slope, approximately 3:1 below Elevation 2568 and 2:1 above Elevation 2568. The slope of the downstream face of the dam is 2:1. There is a 16-foot-wide road and at Elevation 2464 a 97-foot-wide berm on the downstream face.

The spillway was relocated and reconstructed to a spillway crest elevation of 2568 feet, which is 24.5 feet higher than the original spillway crest. The freeboard is 14 feet. The spillway is 80 feet wide at the crest, and is located on the left (east) side of the dam. The spillway channel is constructed of reinforced concrete with a length of 615 feet, and at its downstream end there is a flip bucket. An unlined stilling basin comprised of exposed rock is located below the flip bucket.

Conditions of concern by DSOD related to the spillway were discussed at the DSOD meeting on July 6, 2017 and will be incorporated into the work plan. Seasonally, seepage has been observed from several of the weep holes in the upper portion of the spillway channel, and some sediment has been observed emanating from the weep holes. Possible leakage has also been observed in several of the joints in the upper portion of the spillway channel. It is possible that this leakage could be gradually transporting particles, and therefore could be creating voids underneath the joints due to erosion of particles, which eventually could significantly affect the performance of the spillway.

Another spillway concern is the possibility of adverse impacts on the stability of the spillway walls and concrete chute slab due to the seasonal presence of high groundwater levels in the adjacent soils. GENTERRA has recommended that PID consider analyzing the design parameters of the spillway walls and chute slab to determine if they were designed to withstand the pore pressures resulting from the high groundwater levels which are being measured in that area. GENTERRA has also recommended that PID clear out the sediment that is partially plugging the drains in the flip bucket so that the standing water can drain freely from the flip bucket, and that PID remove any vegetation from the construction joints in the spillway chute.

A.4 Background for Proposal

The condition assessments of the spillways are being requested by the DSOD as a result of the recent major incident at Oroville Dam, which led to significant damage and erosion of the Service and Emergency Spillways for Oroville Dam. To strengthen the State’s inspection program, the Governor has ordered detailed evaluations of dam appurtenant structures, such as spillways. The two PID dams are included in the list of dams selected for detailed re-evaluations due to their sizes and their high-hazard classifications.

The DSOD completed a reconnaissance-level assessment of the spillways at Magalia Dam and Paradise Dam and they had noted that these structures may have potential geologic, structural, or performance issues that could jeopardize their ability to safely pass a flood event. Therefore, the DSOD is requesting that PID perform a comprehensive condition assessment of each spillway as soon as possible. The assessments are being phased, as requested by the DSOD, who approved the

Phase I Work Plans by letter dated October 3, 2017. In a letter from DSOD to PID dated July 12, 2017, they note that these spillways may require site investigations to provide supporting information for completing these assessments. The site investigations, as needed, would be addressed in the Phase I reports and any required Phase II Work Plans.

A.5 Purpose of Proposed Work

The purpose of GENTERRA's proposed services is to implement the approved Phase I Work Plans for each spillway. The work plans present the details of planned programs to perform documentation review, field evaluations, geologic reconnaissance and mapping, initial limited non-destructive field testing and, as necessary, any detailed condition assessments of each spillway including an evaluation of the concrete linings, the existing drainage systems, and any potential for slab undermining and hydraulic jacking. The DSOD states that the scope of the site investigations should focus on identifying potential geologic hazards associated with each spillway, including characterization of the foundation materials underlying and adjacent to the spillway structures and their susceptibility to erosion and instability.

A.6 Organization of this Proposal

This proposal is organized to expedite review and approval by PID. This Section A presents an introduction with the background information, including description of both dams and purpose of the proposal; Section B briefly discusses the areas of expertise of GENTERRA, the relevant experience of our firm, and our firm's strong familiarity and experience with the State Division of Safety of Dams; Section C presents the proposed Project Team and a brief summary of the qualifications of our proposed Project Manager and other Lead personnel; Section D describes our proposed general approach for both spillways; Section E presents our proposed specific approach and scope of work for the Magalia Dam spillway; Section F presents our proposed specific approach and scope of work for the Paradise Dam spillway; Section G presents a summary and general outline of the Phase II Spillway Condition Assessment, if required, for either dam; Section H discusses our proposed review and coordination task, Section I discusses the proposed Project Schedule; and Section J presents the estimated fee and hours with a breakdown of the estimated costs and hours by task.

SECTION B. DESCRIPTION AND EXPERTISE OF TEAM

B.1 Description of Firm

GENTERRA Consultants, Inc. (GENTERRA) will be the Prime Engineering Consultant for the proposed scope of services. A geophysical subcontractor, TerraPhysics, will be used for the geophysical surveys identified in the scope of work, except for the Impact Echo readings using GENTERRA's own equipment.

In GENTERRA's proposal to PID of July 13, 2017 for development of the Phase I Work Plans for each spillway, we presented the areas of expertise of GENTERRA, the relevant experience of our firm, our firm's strong familiarity and experience with the State Division of Safety of Dams, and a brief summary of the qualifications of our proposed Project Manager. We are not repeating the detailed information again in this proposal, but we briefly summarize them below and refer PID to our approved proposals of July 13, 2017 for more detailed information.

The specialization at GENTERRA is engineering for dams and appurtenances. GENTERRA has worked on 160 dams since the founding of the firm in 1995. GENTERRA offers a full range of civil engineering and geotechnical consulting services for all types of projects, with emphasis on those involving proposed, new, and existing dams and reservoirs, levees, channels, canals, and other water storage, water conveyance, flood control, and infrastructure facilities. The firm also provides civil engineering, geotechnical and water resources services for planning, design, construction, evaluation, and modification of other types of facilities. Our specialized capabilities are provided by a team of more than 30 professionals with high levels of technical and management expertise and experience in areas that include the following disciplines and types of facilities:

- ✓ Civil engineering and geotechnical engineering for dams, spillways, channels, levees, canals, rivers, and other facilities for water storage, water conveyance and flood control
- ✓ Geotechnical engineering for all types of facilities
- ✓ Earthquake engineering and seismicity
- ✓ Geology and engineering geology
- ✓ Hydrology, hydraulics, and water resources
- ✓ Hydrogeology and groundwater studies
- ✓ Feasibility studies and engineering for low-head hydroelectric facilities
- ✓ Dam safety risk analyses
- ✓ Support for environmental studies and permitting
- ✓ Expert witness review and testimony

B.2 Project Experience

Since its founding in 1995, GENTERRA has provided consulting engineering services on more than 160 dams in the United States, with 115 of them in California and under the jurisdiction of the DSOD. The services included dam safety evaluations; spillway condition assessments; geotechnical and structural condition assessments of appurtenant structures; geological and hydrogeological investigations, geotechnical field and laboratory investigations; evaluation of stability under static and seismic conditions and overall safety; design and development of plans and specifications; construction observation and consultation; design and installation of instrumentation; coordination with State, Federal and local regulatory agencies; performance of dam failure inundation studies; risk assessments; and assisting in preparation of emergency action plans.

Over the past 22 years, GENTERRA has provided condition assessment or field evaluation services on more than 50 spillways associated with dams in California that are under DSOD. Our firm is currently providing services associated with spillways on several dams under the jurisdiction of the DSOD, including dams in northern, central, coastal and southern California. The scope of our current work related to spillway damage and rehabilitation is confidential at this time.

GENTERRA prepared the Summary of Known Issues and Phase I Work Plans for the Magalia Dam and Paradise Dam spillway condition assessments, which were approved by the DSOD.

B.3 Familiarity with California Division of Safety of Dams

GENTERRA and our personnel have extensive experience in conducting reviews through the California Division of Safety of Dams (DSOD), as gained from 115 dams on which GENTERRA provided services are under the jurisdictional review of the DSOD. That equals about 9% of all the dams under DSOD statewide.

SECTION C. PROPOSED PROJECT TEAM

C.1 Project Personnel Required for Both Spillways

The following professional personnel are proposed to perform the Phase I work, as well as the Phase II work if it is required. The names of the lead GENTERRA personnel that participated in the development of the approved Work Plan are shown in parentheses:

- Project Manager and Principal-In-Charge (Joseph J. Kulikowski, PE, GE)
- Geotechnical Engineer (Soma Balachandran, PhD, PE, GE)
- Civil Engineer, Hydrology & Hydraulics (Douglas A. Harriman, P.E., LEED AP)
- Engineering Geologist (Michael Wolff, PG, CEG)
- Structural Engineer (Chuck Hutton, PE)
- Field and Laboratory Technician (J. William Kulikowski)

Other professionals, as well as Project and Staff level personnel, will also provide review and support. All personnel are employees of GENTERRA.

GENTERRA's personnel identified above would be assigned to perform the Phase I work and the Phase II work, if it is required. Resumes are available and can be submitted, if needed. Please note that we are billing several team members at classifications lower than their normal fee schedule classifications, in order to reduce costs to the PID.

Presented below are brief summaries of the experience and qualifications of the key project personal. Resumes were included in GENTERRA's July 13, 2017 proposals for the development of the work plans. The resumes present comprehensive information on relevant experience; professional certifications, licenses and registrations; education; and project experience.

The **Project Manager and Principal-In-Charge** will be **Joseph J. Kulikowski, P.E., G.E.**, President and Senior Principal Engineer of GENTERRA, is the GENTERRA Team's designated Project Manager and Principal-In-Charge for the proposed services. He will be the supervisor/administrator of the project staff and will be responsible for the delivery of services in accordance with the established Scope of Services.

Mr. Kulikowski has a degree in Civil Engineering and has done graduate study in civil engineering, geotechnical engineering and engineering management. He is a Registered Civil Engineer and a Registered Geotechnical Engineer in the State of California, and is a Professional Engineer in 10 other states.

Mr. Kulikowski has more than 45 years of experience in civil and geotechnical engineering, with most of that time involved with the design and evaluation of dams in California and other states. He spent seven years early in his career as an engineer with the State Division of Safety of Dams (DSOD) in Sacramento and other California locations performing design review, construction inspections and reviews, dam safety structural condition assessments, dam safety monitoring review, and a special review of all dams in California. Since then, he has been a Principal with consulting firms specializing in dams in California and other states.

Mr. Kulikowski has extensive experience in coordination and reviews with DSOD representatives. He has personally evaluated more than 300 different dams in California and other states, personally performed more than 1,000 dam safety inspections, and had responsible role for the design of more than 30 new or modified dams in California, other states and South America.

The **Lead Engineer for Geotechnical and Seismic Engineering and Assistant Project Manager** will be **Dr. Soma Balachandran, Ph.D., P.E., G.E.**, a Principal Engineer with of GENTERRA, who has more than 30 years of experience in geotechnical and civil engineering, and has provided services on more than 50 dams. He has more than 30 years of consulting, teaching, and research experience in the field of geotechnical engineering. He has been employed full-time with GENTERRA since 2005. Since 1997, he has been mainly involved in the geotechnical consulting profession as a project engineer, project manager and project coordinator specializing in geotechnical investigations and evaluations, evaluations and design of dams, slope stability analysis, design of reinforced walls/slopes, seismic analysis and numerical modeling of demanding geotechnical conditions using finite element and finite difference computer programs. He has worked on numerous geotechnical investigation projects around the world. Dr. Balachandran is a Registered Civil Engineer and a Registered Geotechnical Engineer in the State of California.

Dr. Balachandran is the Lead Geotechnical Engineer for GENTERRA's current contracts for dam safety evaluations that are under jurisdiction of the DSOD, including an ongoing contract for dams in northern California, the Bay Area and the Sierras as the dam safety subconsultant on a team for Pacific Gas & Electric Company (PG&E); As-Needed Engineering Design and Support Services to the Water Resources Division, Dams Group, of the County of Los Angeles Department of Public Works; and several other dam safety evaluation contracts in California. Dr. Balachandran is also the lead design engineer responsible for the award-winning Eagle Canyon Dam project in Palm Springs, California. He is also the lead engineer on current spillway assessment and rehabilitation projects.

Dr. Balachandran has performed advanced engineering analyses for several geotechnical investigation projects in California and prepared geotechnical investigation reports providing the data collected, and recommendations for site-specific response spectra, liquefaction potential, liquefaction settlement, site type and seismic zonation. He also has extensive experience in providing recommendations for liquefaction remedial measures such as stone columns and soil/cement techniques. Dr. Balachandran has several years of experience in numerical modeling of demanding geotechnical conditions using finite element and finite difference computer programs, such as FLAC. Dr. Balachandran has published many technical papers in international geotechnical engineering journals, which include the ASCE Journal of Geotechnical Engineering, and Geotechnique.

The **Lead Engineer for Civil Engineering, Hydrology and Hydraulics** will be **Douglas A. Harriman, P.E.,** a Principal Engineer with GENTERRA. ***He will be billed at the Senior Associate rate, which is lower than his Principal rate***. He is a Registered Civil Engineer in the State of California. He is a member of the American Society of Civil Engineers (ASCE), the U.S. Society on Dams (USSD), and the Association of State Dam Safety Officials (ASDSO). Mr. Harriman has more than 20 years of experience in the evaluation of dams from the standpoints of dam safety, hydrology and hydraulics. His experience includes thorough inspection and conditions assessment of dams and appurtenant structures, making visual observations of key features of dams, spillways and outlet works, collection and analysis of field data, and evaluation of instrumentation data. Mr. Harriman performs field and office studies involving hydrology, including Probable Maximum Precipitation (PMP), inflow design floods such as Probable Maximum Flood (PMF), hydraulics of flow through structures, dam-breach inundation studies, and assessment of hydrogeology, water quality, and other aspects of hydrology on many projects.

The **Lead Engineering Geologist** will be **Mr. Michael Wolff, P.G., C.E.G**., a Principal Engineering Geologist for GENTERRA. ***He will be billed at the Associate rate, which is lower than his Principal rate.*** He is a Professional Geologist and Certified Engineering Geologist in California. Mr. Wolff provides engineering geology for projects involving the design and evaluation of dams, reservoirs and other facilities. He has 37 years of professional experience as a consulting geologist and engineering geologist. His experience includes a wide range of engineering geology, engineering and construction projects. In all, Mr. Wolff has managed or directed more than 300 site investigation projects at commercial/industrial and public-sector sites.

The **Lead Structural Engineer** will be **Mr. Chuck Hutton, P.E., a Principal Engineer with GENTERRA.** ***He will be billed at the Senior Associate rate, which is lower than his Principal rate.*** He is a civil/structural engineer with 40 years of experience in the development of water resource projects involving dams, hydropower, pumping plants and water conveyance systems in the United States, Asia, Latin America and the Middle East. His expertise includes design of dams and appurtenant structures for dams and reservoirs; dam safety inspections; condition assessments of existing dams, hydropower facilities and canal systems; developing designs for rehabilitation, project management and construction management. He spent the first 15 years of his career with the Bureau of Reclamation in Denver, Colorado followed by 23 years with ECI. His extensive experience includes concrete, roller-compacted concrete (RCC), rockfill and earthfill dams. He has directed and participated in the preparation of designs, drawings, specifications, cost estimates and economic and financial analyses for dams, hydroelectric power plants, pumping plants, pipelines, canals and hydraulic structures. He has managed projects involving field investigations; site surveys; geotechnical and engineering geology investigations and analysis; hydrologic/hydraulic analysis; structural stability and stress analysis and design; mechanical engineering for gates and valves; electrical engineering for instrumentation and controls; and construction management.

Engineering Support for Geotechnical and Structural Engineering will be provided by **Mr. Shuyu Liu, P.E**., a Senior Project Engineer with GENTERRA. ***He will be billed at the Project Engineer rate, which is lower than his Senior Project Engineer rate***. He has more than 25 years of experience as an engineer and researcher in the field of geotechnical and structural engineering, including geotechnical investigation, engineering analyses and calculations, earthwork monitoring and field density testing, geologic and seismic hazard studies, analysis and stabilization of slopes, design of earth retaining structures, deep foundations, design of in-situ testing plans, special structural analysis and design. Mr. Liu has extensive engineering experience on more than 30 dams, especially earthfill dams in California under the DSOD review. He has performed geotechnical dam safety evaluations, stability analyses, seepage analyses, site investigations, instrumentation design and other studies. He has expertise is in-situ instrumentation, monitoring and testing of geotechnical and structural projects and data acquisition systems. Mr. Liu has extensive expertise in computer programs WINSTABL, FLPIER, MSEW, LPILE, ALLPILE, SLOPE/W, SEEP/W, EQSEARCH, LIQUEFYPro and is familiar with PLAXIS, SAP2000, AutoCAD, ANSYS and ABAQUS. Mr. Liu is a registered Professional Engineer in California.

The **Lead Field Technician** with be **J. William Kulikowski**, a Supervising Technician with GENTERRA and Manager of Field and Laboratory Services. ***He will be billed at the Senior***

Technician rate, which is lower than his Supervisory Technician rate. He has more than 20 years of experience in inspections and evaluations of dams and other facilities, and materials evaluations and testing for soils, concrete, asphalt, soil cement and geosynthetic materials used in construction, repair and maintenance of dams, spillways, outlet works, roads, bridges and other structures and facilities.

Geology Support and CAD Drafting using Computer Aided Design (CAD) will be performed by **Ms. Kristina M. Mohos**, a Senior Staff Geologist and CAD/GIS Technician with GENTERRA with more than 8 years of experience. She specializes in geology projects relating to dams, water resources, hydrology, environmental issues and water quality. She performs geological fieldwork and data analysis, writes reports, reviews documents, prepares and reviews construction plans, communicates with clients, subconsultants and review agencies, and is proficient in GIS, MicroStation, AutoCAD and AutoCAD Civil 3D.

GENTERRA also plans to subcontract for the services and equipment of a qualified and experienced Geophysics company that has done extensive work with GENTERRA on investigations of dams and appurtenances. The name of the Geophysics firm that will be used by GENTERRA for the work described in the Phase I Work Plan is Terra Physics, and they participated in the development of this Phase I Work Plan. Information about Terra Physics can be provided, if needed.

If Phase II is required, the same personnel and Geophysics firm would be used, but additional services would be subcontracted for exploration subcontractors for drilling, coring, in-situ testing and trenching, and also for more comprehensive Non-Destructive Testing and evaluation, concrete coring and testing, geotechnical drilling and sampling, and installation of instrumentation.

SECTION D. APPROACH AND SCOPE OF WORK FOR BOTH SPILLWAYS

D.1 General Approach and Scope for Both Spillways

GENTERRA will follow the Work Plan prepared by GENTERRA and approved by the PID and the DSOD for the Phase I Spillway Condition Assessment for both dams. The work will cover the document review and evaluation; field evaluations; geologic reconnaissance and mapping; non-destructive field testing and evaluation; a summary report of Phase I findings and recommendations; and coordination with PID and the State DSOD. Phase II could include, as determined necessary upon completion of Phase I, detailed site investigations consisting of non-destructive evaluations and drilling including coring of the spillway slab, sampling of concrete and subsurface materials; laboratory testing; engineering analyses; and report preparation, review and submittal.

GENTERRA will maintain good communications with PID and the DSOD, as well as among team members, for an effective implementation of the work at both dams. We will need to provide the DSOD with at least 72-hours-notice when the field evaluations are scheduled so that they have an opportunity to be present during part or all of the time.

GENTERRA will also integrate efforts being applied and information obtained from our other services being provided to PID as the dam safety consultant on both dams under a current 3-year contract. This will enable overlap and effective integration of the main aspects of the overall project from the perspectives of all applicable disciplines of engineering and geosciences.

A key consideration during the implementation of the Phase I Work Plans for both spillways will be the unique ability of GENTERRA to be efficient and cost-effective in the cross-utilization of project personnel on all services and all issues on both dams. That will provide us with the ability to schedule various tasks and subtasks in the proper sequence and use information from each deliverable into subsequent deliverables and phases. We will also be able to help PID in identifying, prioritizing, planning and implementing needed remedial measures for each spillway to the satisfaction of the DSOD.

SECTION E. SPECIFIC APPROACH & SCOPE FOR MAGALIA DAM SPILLWAY

E.1 Specific Approach for Magalia Dam Spillway

The following work is included in the Phase I Work Plan for the Magalia Dam spillway to address Known Issues in Section 3 of the approved Phase I Work Plan, as well as other items to provide a comprehensive spillway condition assessment.

All of the proposed tasks for Magalia Dam will be performed consistent with the approved Phase I Work Plan. The Phase I Spillway Condition Assessment will be valuable to tailor the assessment and possibly avoid a Phase II site investigation and for development of tailored cost-effective Phase II site investigation and field testing programs in a credible and cost-effective manner.

The planned Phase I work includes the steps needed to evaluate the current conditions of the distressed areas (or potentially distressed area or potential to have undetected distress or potential to have future distress) of the spillway, the likely cause(s) of the damage to the spillway, and commence consideration of potential fixes for the damaged areas of the spillway (if needed), together with a ranking of the relative importance and potential scheduling of those remedial measures. Ballpark cost, permitting and other related issues will also be discussed and compared.

Based on the results of the Phase I work, additional field investigation may be needed as Phase II, and would be described in more detail when it is developed after completion of Phase I.

The proposed Phase I Spillway Condition Assessment includes the following steps:

Review available documents and issues in this report;

Perform a visual inspection to document the extent and severity of any distress or deterioration on the spillway structures;

Obtain measurements of the approximate extents of the distressed and delaminated areas;

Develop a detailed photographic record of the distressed portions of the spillway and the surrounding area;

Conduct a detailed visual inspection of the spillway slab documenting locations of irregularities and weaknesses that could affect flow resulting in cavitation. We will document locations on drawings and obtain photographs;

Perform a visual internal inspection of the weep holes in the left wall and cutoff walls and any uplift relief valves (if they do exist) in the concrete slab constructed in 1955 using a flashlight and/or a portable pipeline video camera, whichever is suitable;

Use the “chain drag” method to identify the extents of delaminated portions of the spillway;

Perform hammer sounding testing to supplement the chain drag method and to identify the extent of delaminated portions of the spillway;

Mark the extent of the estimated limits of delamination and distressed areas using white marking paint;

Perform geophysical surveys to measure the thickness and integrity of the concrete in the spillway slab and walls using GENTERRA's Impact Echo instrument;

Perform geophysical non-destructive surveys of the spillway and the adjacent areas to determine concrete conditions, subgrade conditions and subsurface groundwater profiles. These procedures will include the following methods: GPR Survey, MASW Survey, Seismic Refraction Survey, and Impact Echo Testing;

Perform a geologic reconnaissance and delineation of features, especially for any discontinuities, fractures, faults, and other geologic features along the spillway channel;

Perform limited geotechnical and structural stability analysis of the left and right spillway walls based on available and assumed material properties for the concrete, backfill and foundation materials, and use of an appropriate seismic coefficient for pseudostatic analysis;

Evaluate results of the Phase I field work and develop comments and recommendations; and,

Preparation of a Phase I Spillway Condition Assessment Report and Phase II Work Plan, if needed.

E.2 Objectives of Field Work in Phase I for Magalia Dam Spillway

The following items regarding the spillway slab will be investigated in Phase I for the Magalia Dam Spillway:

Determine the concrete slab thickness using GPR and Impact Echo testing;

Determine the condition of the concrete in the slab using Impact Echo testing;

Investigate if there are voids beneath the spillway slab and/or backfill concrete using GPR;

Determine the approximate locations, approximate spacing, and approximate bar sizes of reinforcing steel in the slab using GPR;

Determine if steel anchor bars exist to anchor the spillway slab to the foundation using GPR; and,

Determine existing delamination of the spillway slab by dragging a specially-fabricated chain device over the surface of the spillway slab.

Using the results of the above investigation, we will prepare a composite drawing showing all locations of distress, damage, cracking, movement and other features, as well as slab details such as thickness, reinforcement, and anchors.

Items are to be investigated regarding the right spillway wall:

The wall appears to be tilting away from the backfill. Check if the wall is plumb using a level or plumb bob and record the results. This will be performed at multiple locations along the wall;

The wall appears to be socketed into the rock foundation without a footing; we will verify foundation condition using GPR;

Check the approximate wall thickness using GPR and Impact Echo instrument readings;

Use GPR to approximately locate wall reinforcements and their approximate sizes;

Estimate the condition of concrete in the wall using Impact Echo instrument readings; and,

Evaluate the soil backfill using a MASW (multi-channel analysis of surface waves) survey and probing.

Items are to be investigated regarding the left spillway wall:

Check the wall thickness using GPR and Impact Echo instrument readings;

Use GPR to approximately locate wall reinforcements and their approximate sizes;

Estimate the condition of concrete in the wall using Impact Echo instrument readings;

Investigate the weep holes to determine if they are functional to drain backfill by visual examination with a flash light and/or camera; and,

Investigate the potential impact of the weep holes during future spill events.

Evaluation of rock erodibility:

This evaluation will be made by visual observations of discontinuities in the rock and their orientations relative to the alignment of the spillway channel;

Obtain information regarding the Magalia Fault:

Use seismic refraction profiles to delineate change in bedrock properties associated with the fault and identify layers that could have the potential for erosion during a spill event. Seismic refraction may give a general idea about the orientation of the fault, but it would not be used for obtaining distinct features within the bedrock mass.

E.3 Proposed Tasks of Phase I for Magalia Dam Spillway

Task M-1: Document Acquisition and Review

In this task, GENTERRA will visit the offices of the DSOD located in Sacramento, California to obtain internal DSOD documents such as reports, photos, memoranda and correspondence that were prepared by DSOD after 2002, which was the year in which document acquisition was previously done by GENTERRA for PID. As related to PID's files, we have already received electronic files of pertinent plans, reports, photos, DSOD communications, and other pertinent data related to the design and construction of the dam, as well as any identified conditions or concerns, changes or upgrades made to the dam. During the DSOD visit, as necessary, we will also ask questions regarding any past or current issues with DSOD personnel. During the visit to DSOD, or in separate discussions by phone or Email, we will discuss with DSOD representatives regarding their expectations for remedial repair. We will also discuss with the DSOD and PID any other issues identified in the files that are related to the spillway structure.

Electronic copies will be made of pertinent documents from the DSOD for our use in the evaluation and for submittal to PID for inclusion in their files for the dam. The extent of the files designated for reproduction will be determined with PID concurrence once GENTERRA identifies the files and obtains a cost estimate from the DSOD-approved reproduction company. These files will be used by GENTERRA personnel in document review to be performed in this task.

A preliminary list of the documents to be reviewed in this task is presented below and was also presented in Attachment C of the approved Phase I Work Plan. During our review, attention will be paid to known issues that were discussed in Section 3 of the approved Work Plan as well as to any other issues that may be of concern to the safety of the dam and spillway.

1) Construction Documents
   - As-Built Plans
   - Construction Specifications
   - Construction Reports
   - Reconstruction Reports, Plans and Specifications

2) Technical Documents from GENTERRA Files and Other Sources
   - Engineering Reports
   - Geologic Reports
   - Magalia Fault Evaluation Reports

3) Annual Dam Safety Surveillance Reports
   - Annual Dam Safety Surveillance Reports by GENTERRA
   - Annual Dam Safety Surveillance Reports by Others
   -

4) Inspection Reports
   - Inspection Reports by GENTERRA

- Inspection Reports by DSOD
- Inspection Reports by Others

5) Repair and Maintenance Records
   - Repair and Maintenance records by PID
   - Repair and Maintenance records by Others

6) Photographs
   - Photographs Taken During Construction
   - Photographs Taken During Inspections by GENTERRA
   - Photographs Taken During Inspections by DSOD
   - Photographs Taken During Inspections by Others

7) PowerPoint Presentation Slides used by DSOD During the Meeting held on July 6, 2017 amongst DSOD, PID, and GENTERRA and Notes Taken During Meeting by Joseph J. Kulikowski of GENTERRA

8) Documents from DSOD Files
   - Additional Documents will be acquired from DSOD Files during Phase I

9) Other Documents from PID Files and Other Sources

Task M-2: Field Evaluation and Non-Destructive Evaluation

GENTERRA personnel will perform the field evaluation task after completion of the review of the available pertinent documents. We will notify DSOD of our field evaluation schedule at least 72 hours in advance so that DSOD personnel can also participate in the field evaluation to be performed.

In this task, key GENTERRA team professionals will visit the site of the spillway structure and spillway channel with personnel from PID to visually observe conditions and to gather available site data. The following individuals are expected to participate in the site visit: Joseph J. Kulikowski, P.E., G.E. (Principal-In-Charge/Project Manager); Soma Balachandran, PhD, P.E., G.E. (Principal Engineer/Geotechnical Engineer); Michael Wolff, P.G., C.E.G. Principal Engineering Geologist; Chuck Hutton, P.E, Principal Structural Engineer; and J. Will Kulikowski (Field Technician). The main purposes of the site visit are to gain a visual understanding of the extent of the existing damage/distress, visual condition of the existing spillway structure and spillway channel, and to verify and refine information on access for field work that was presented in the approved Work Plan. Site constraints and operational limitations that could affect the condition assessment discussed in the approved Work Plan and construction access for repair work, means and methods to perform will also be evaluated during the site visit.

During the site visit for field evaluation, GENTERRA will perform a detailed inspection of the conditions of all transverse and longitudinal joints, including but not limited to offset, opening, slab tilting, bulging, edge spalling, and potential for water to flow through joints. GENTERRA will also perform hammer sounding at accessible locations in and around the existing damage for signs of concrete delamination. Since the spillway crest area is relatively level, we should be able to access the distressed area of the spillway structure in a safe manner. While surface testing results are not comprehensive, hammer testing is considered good practice to accompany visual observation and could assist in refining the work discussed in the approved Work Plan. In this site visit, we will attempt and apply other techniques, such as chain dragging, to obtain information regarding concrete delamination. We will also use GENTERRA's Impact Echo instrument to evaluate the thickness and integrity of the concrete at selective locations.

This field evaluation will enable GENTERRA representatives to become familiar with the existing structural features, configuration, and overall condition of the spillway structure. We believe that early detection of even small problems can result in significant reduction of future operational and maintenance costs.

During the site visit, we will interview PID's maintenance representative to assess whether routine maintenance and minor repair procedures are adequate or need improvement. Based on that information, GENTERRA may suggest to PID any feasible improvements to routine maintenance and repair procedures.

Based on our field evaluation, GENTERRA may refine the field work that is discussed in Tasks M-3 and M-4 in the Phase I Work Plan. Any needed refinement to the field work will be discussed with PID and DSOD before implementation of such change during the field work. Any needed change(s)/refinement(s) will be communicated in a timely manner to PID and DSOD to avoid any delay in the field work activities.

The following discussion is provided to supplement the details in the Phase I Work Plan and to explain why it is important for an experienced structural engineer, an experienced geotechnical engineer and an experienced engineering geologist to participate in the field evaluation in the Phase I activities.

In order to perform a proper and complete concrete condition assessment, the structural engineer should participate in the Phase I site visit and visual inspection to personally observe, map and record the nature and extent of concrete cracks, spalls and other deterioration. A visual inspection of the exposed concrete by the structural engineer is the first step in an on-site examination of a structure. Visual inspection is one of the most versatile and powerful NDT methods. However, its effectiveness depends on the knowledge and experience of the investigator. The purpose of such an examination is to locate and define areas of distress or deterioration. It is important that the conditions observed be described in unambiguous terms that can later be understood by others who have not inspected the concrete. The results from the Phase I on-site inspection and evaluations will be used to prepare the plan for any required Phase II investigations. In addition, the hammer sounding and chain dragging should be performed in the presence of (or personally by) a structural engineer with previous experience in conducting these investigations. A trained and experienced ear is required to evaluate the results from these tests.

An experienced geotechnical engineer and an experienced engineering geologist will provide valuable input for the subject. While the structural engineer can identify existing issues, input from the geotechnical engineer and an engineering geologist is very vital to understand the underlying causes related to the some of the observed distress in concrete. When it comes to evaluating unprotected spillway channel, it will be the responsibilities of a geotechnical engineer and an engineering geologist. In any project, an engineering geologist and a geotechnical engineer develop recommendations for the structural engineer by studying the local geology and by evaluating the subsurface properties. Without properly understanding the history of the project site and knowing the engineering properties of the subsurface materials, a structure cannot be properly evaluated and rehabilitation designed and constructed.

All in all, a team consisting of an experienced geotechnical engineer, an experienced engineering geologist, and an experienced structural engineer is very important for the subject project to identify the causes for observed distress and to develop cost-effective remedial measures.

Task M-3: Geologic Reconnaissance and Surficial Mapping

As the first step of this task, an Engineering Geologist will characterize the geologic and seismic setting of the site based on existing information and information that will be gathered in this task by conducting an initial review of published geological literature, USGS/California Geological Survey (CGS) maps, regional geologic maps, and other geotechnical data pertinent to the site, including the documents that are listed in Attachment C.

Available aerial photography will be obtained and analyzed for evidence of photolineaments that may be related to underlying geologic structures, including the Magalia Fault. In addition, aerial photos will be analyzed for signs of existing or potential slope instability. Any suspect features identified in the aerial photo analysis will be flagged for field examination in the geologic reconnaissance activity. Surficial geologic mapping will be performed to validate and update existing site geologic map.

We will notify DSOD of our field work schedule related to the geologic reconnaissance and surficial geologic mapping at least 72 hours in advance so that DSOD personnel can also participate in the field evaluation to be performed.

The geologic mapping will focus on the following issues:

- Geologic conditions adjacent to the spillway structure;

- Faulting;
- Discontinuities in exposed bedrock along the spillway channel; and,
- Information needed for erodibility studies, such as joint spacing, orientation, degree of jointing or fracture in a rock mass, etc.

As part of this task, an updated site geologic map will be prepared for use in the Phase I Spillway Condition Assessment as well as to refine the planned geophysical work discussed below.

The following discussion is provided to supplement the details in the Phase I Work Plan and to explain why it is important for an experienced engineering geologist to participate in the field evaluation in the Phase I activities.

A visual inspection of all of the observable geologic features will be critical to developing an integrated technical understanding of the fundamental role that geologic processes play in exacerbating or mitigating observed issues affecting the safety and performance of the spillway. Such observations will enable optimization of the planned geophysical work in Phase I, and will also benefit the selection of any required Phase II invasive studies such as fault trenching or piezometer installation should such activities be warranted and recommended for Phase II. In Phase I, the engineering geologist will personally record key geologic metrics such as apparent rock quality designation (RQD), rock discontinuity orientations, shear zone characteristics, and groundwater seepage zones, to name but a few. The geologist will personally take photographs of observed features for later study and incorporation on maps and other project record documents. By observing features and collecting data first hand, the engineering geologist will be able to apply his wealth of experience to optimize the value realized in the important first phase of the work.

Task M-4: Geophysical Survey

Detailed Descriptions of Geophysical Surveys for Specific Issues

The Phase I Spillway Condition Assessment will include geophysical surveys to address the stated concerns/issues regarding the spillway slab and walls, and subgrade conditions. ACI 228.2R-13 (2013) recommends and describes how to apply the appropriate methods for the issues that were presented in Section 3 of the approved Work Plan. Geophysical surveys will be conducted in accordance with ASTM standards. Results will be correlated with available geotechnical, geological, and hydrogeologic information to quantify problem areas and establish their lateral and vertical extent possibly for further investigation in Phase II, if necessary.

Presented in this Section are details of the geophysical methodologies and equipment to be used specifically for Issues Numbers 1 through 11 listed and described in Section 3 of the Phase I Work Plan.

Proposed Phase I Geophysics Survey for Issue No. 2 – Spillway Floor Slab Damage

The spillway concrete floor slab (about 140 feet NW x 76 feet NE) visually appears in poor shape (See Attachment B, Photographs M2-1 through M2-8 in the Phase I Work Plan). Records review provides little information about spillway design, construction, maintenance, and contains no indication of rebar or drains and anchors under the floor. A DSOD report says that the concrete floor is 6 inches thick. Characterizing the concrete's condition could include detection of air and water filled voids, pipes, rebar (and more importantly missing rebar), and structural elements. Subgrade drains, erosion areas (especially caused during the 1930 flood), and possibly shallow saturation zones in the underlying soils could also affect concrete stability.

All these features have distinctly different dielectric values that can be detected by a ground penetration radar survey. ACI recommends radar for investigating concrete structures. The literature lists dielectric values (this quantity has no dimensions) for concrete is in the range of 7 to 11. The features of interest have measurably different values, air filled void (1), metal objects (very high), water filled void (81), dry sandy soil (3-5), and saturated sandy soil (25-30), so they form recognizable anomalies relative to the concrete. Radar data (see Figure M4 of the Phase I Work Plan for an example radar survey) can detect vertical and lateral dielectric changes as an antenna is pulled along a profile.

Figure M5 of the Phase I Work Plan shows the proposed radar survey recommended for Phase I. A series of parallel, northwest oriented profiles that extend across the entire spillway floor could delineate the conditions of concern. A data sampling rate of 40 to 60 data scans per foot and a profile spacing of five feet will provide adequate vertical and lateral resolution to detect small dimension features. Profiles are oriented along the spillway long axis for recording efficiency and safety reasons. The first profile will be as close to the left wall as possible and the last one will be a partial profile parallel with the others that is as close to the right wall as possible (*crooked profiles cannot be processed properly*). Profile ends will be painted on the concrete and their GPS coordinates (tolerance of ±1 foot) will be transferred to the spillway base map. Figure M13 of the Phase I Work Plan shows the general site access to the upstream area where the area of the proposed radar survey is located.

Measurements will be made with Geophysical Survey Systems Model SIR-3000 ground penetrating radar. The system consists of a digital recorder mounted on a cart and a shielded, down-looking antenna. The system sends EM waves from the antenna into the concrete and underlying soil and rock. These waves partially reflect at boundaries between materials with different dielectric properties. The reflected waves are measured by the same surface antenna, digitally stored, and displayed.

Data recording and processing procedures will follow ASTM 6432-11 and 4748-10 guidelines. The most critical measurement parameter for this survey is the choice of antenna frequency. Higher frequency antenna provides higher spatial resolution of subsurface features because the signal's wavelength is smaller. However, the earth acts as an efficient high-cut electrical filter and greatly attenuates the propagation of high frequency EM waves. Penetration decreases at higher frequency because there is more attenuation by the earth's filter. Before production data recording starts, feasibility tests will be conducted at one or two locations on the concrete. Data will be recorded with 400, 500, 900, and 1600 MHz antennas. Real time interpretation will determine the optimum frequency that can resolve the conditions of concern while providing adequate penetration of at least two feet into the underlying soil or rock.

During the production survey, the distance-measuring odometer will be calibrated twice along a 30- to 50-foot measuring tape to confirm that the recorded distances along the profile are properly recorded. The optimum frequency antenna will be manually moved by the operator along one profile at a time. Great care will be taken to keep the antenna traveling in a straight line along each profile that will be temporary marked with a rope or measuring tape. Each profile will be saved as an independent data file. Concrete thickness will be directly measured in Phase II in five one-inch-diameter coreholes drilled with an impact hammer drill. These coreholes will be randomly located at selected data profiles and their locations will be posted on the base map.

Data will be transferred to a Laptop PC and all the standard geometry processing corrections will be applied using GSSI RADAN software. Concrete dielectric values will be iteratively modeled In Phase II at each corehole so that the radar anomaly thickness will match the actually measured concrete thickness. Final dielectric values will be added to all data files. A three-dimensional model will be developed by combining all profiles into one grid. The finished model can display radar anomalies interpreted as subsurface features; the final radar model is a three-dimensional cube with northing, easting, and depth (or elevation) axes. Within the software, a vertical slice of radar data can be exported which will look similar to a cross-section. Also, a flat surface at any depth (or at a particular elevation) can be exported that will look like a contour map of radar signal amplitude. Report figures will be constructed from different sections and depth surfaces chosen to highlight features of interests (rebar spacing, concrete depth, air filled voids). . Concrete thickness can be displayed as a depth contour map on top of the base map. Locations of features within and beneath the concrete will be measured from the model and added to the base map.

Proposed Phase I Geophysics Survey for Issue No. 4 – Right Spillway Wall Backfill

The spillway right side wall may have a stability problem (See Attachment B, Photographs M4-1 through M4-7 in the Phase I Work Plan). This Section addresses the backfill behind the wall. Records review provides no information about the wall footing and the effects of erosion at its base. Geophysical radar surveys to assess the wall footing and effects of erosion are described below for Issues Nos 4 and 5.

During the 2007 bypass pipeline installation, the backfill material immediately adjoining the right wall was reportedly not disturbed. The compaction of this material is unknown and may contribute to the wall tilting.

Backfill conditions can be determined by measuring vertical and lateral changes in seismic shear velocities instead of excavating. Low shear velocities indicate less compaction of the backfill.

Measuring shear instead of the more common compressional velocities is important for this survey because the backfill may be partially saturated. Shear waves are not affected by saturation like compressional waves are. Geotechnical properties (Poisson's ratio and low-strain shear modulus) of the backfill can be estimated from the shear velocity models.

Vertical variations of shear velocities can be determined by measuring the dispersion of surface waves with frequency using the multi-channel analysis of surface waves (MASW) technique. It uses an active seismic source to generate the waves that are recorded by an array of geophones (vibration sensors). Figure M6 of the Phase I Work Plan is an example of a cross section of four independent MASW vertical soundings that shows the two-dimensional distribution of shear velocities. Three zones of less compacted soils were interpreted as causing the three velocity inversion zones.

Figure M7 of the Phase I Work Plan shows the proposed MASW survey recommended for Phase I. The four, northeast oriented, cross sections will be spaced about 15 feet apart and located about 5, 20, 35, and 50 feet southwest of the right wall northwest end. Each cross section consists of three independent MASW soundings. Their centers will be about 2, 10, and 20 feet from the wall. If the backfill immediately against the wall is less compacted, then the sounding located 2 feet from the wall will have lower shear velocities than the sounding 20 feet from the wall. Sounding center locations will be staked and their GPS coordinates (tolerance of ±1 foot) transferred to the spillway base map. Figure M13 of the Phase I Work Plan shows the general site access to the upstream area where the area of the proposed radar survey is located.

There are no ASTM procedures for Surface Wave soundings, so the U.S. Army Corps of Engineers procedures will be followed. Seismic waves will be generated by striking a 20-pound hammer on a metal plate lying on the ground. The waves will be sensed by twelve Mark Products model L-4 (4.5 Hz resonant frequency) geophones spaced 2-4 feet apart along an array. Their signals will be recorded on a Geometrics R-48 digital seismograph. Data records will be made with the hammer source located about 5, 20, and 60 feet off all array ends. Penetration should be at least 30 feet.

Each MASW sounding will be modeled with SEISIMAGER software. The first step in data reduction is to edit the data and calculate a dispersion curve of seismic phase velocity versus frequency for each record. These curves are edited and combined to form a composite curve of both active and passive source data. An initial model of vertical shear velocity zones is constructed and a synthetic dispersion curve calculated. This curve is compared to the observed data, adjustments are made to the initial shear velocity model and a new synthetic dispersion curve is calculated. This process continues until an acceptable dispersion curve match is achieved between the synthetic and observed curves (generally less than ±10%). Layer velocity and thickness and their uncertainties will be displayed as vertical models and then grouped into cross sections. Low velocity zones that probably represent low compaction will be highlighted and their locations and depths transferred to the spillway base map.

Proposed Phase I Geophysics Survey for Issues Nos. 4 and 5 – Left and Right Spillway Walls

Record review provides little information about spillway design, construction, maintenance and contains no indication of rebar or drains in either the floor or behind the left and right walls. The walls appear to be thin and a DSOD report says the concrete floor is 6 inches thick. Both walls and their 2-foot-deep footings may become unstable if the spillway floor erodes near the wall (See Attachment B, Photographs M5-1 through M5-8 of the Phase I Work Plan). Characterizing the concrete's condition could include detection of air and water filled voids, pipes, rebar (and more importantly missing rebar), and structural elements. Subgrade drains, erosion areas and possibly shallow saturation zones in the underlying soils and rock and the backfill material could also affect wall stability.

All these features have distinctly different dielectric values that can be detected by a ground penetration radar survey. ACI recommends radar for investigating concrete structures. The literature lists dielectric values (this quantity has no dimensions) for concrete in the range of 7 to 11. The features of interest have measurably different values, air filled void (1), metal objects (very high), water filled void (81), dry sandy soil (3-5), and saturated sandy soil (25-30), so they form recognizable anomalies relative to the concrete. Radar data (Figure M10 of the Phase I Work Plan) can detect vertical and lateral dielectric changes as an antenna is pulled along a profile.

Figure M9 of the Phase I Work Plan shows the proposed radar survey recommended for Phase I. Northwest oriented, floor profiles will be located at three feet and at seven feet from both walls. These data will be combined with data developed for Issue No. 2 to provide high lateral resolution within 10 feet of both walls to detect small dimensional features possibly affecting the footings. Wall profiles will be parallel with the floor and spaced at 1, 2, 3, and 4 feet above the floor.

All profile ends will be painted on the floor and both walls and their GPS coordinates (tolerance of ±1 foot) will be transferred to the spillway base map. Figure M13 of the Phase I Work Plan shows the general site access to the upstream area where the area of the proposed radar survey is located.

Measurements will be made with the same equipment and using the same procedures described for Issue No. 2. For both walls, a concrete thickness contour map of the floor and of the wall will be generated. Locations of features within and behind the walls will be measured from the three-dimensional models and added to the base map.

Proposed Phase I Geophysics Survey for Issue No. 10 – Erosion Related to Magalia Fault

There may be features and discontinuities downstream of the cutoff and under the roadway in proximity to the Magalia Fault that raise concerns about potential erosion (See Attachment B, Photographs M10-1 through M10-6 of the Phase I Work Plan). As part of a geologic review, a seismic refraction profile may delineate bedrock features associated with the fault. Results may also show areas where the alluvium is thicker and may be prone to erosion.

Vertical offsets and shear zones within the bedrock may cause changes in compressional wave velocities that can be detected with surface measurements. Figure M10 of the Phase I Work Plan is an example refraction survey cross section showing lateral and vertical variations of three distinct compressional velocity zones. The upper two zones represent alluvium with varying degrees of compaction. The deeper bedrock velocity shows a relative lower velocity zone associated with fault shearing.

Figure M11 of the Phase I Work Plan shows the suspected Magalia Fault at the spillway on the site geological map. Figure M12 of the Phase I Work Plan shows the proposed seismic refraction survey alignment that is roughly perpendicular to the fault and offset about 100 to 200 feet west of the spillway where surface access is better. The profile will be 250 to 300 feet long. Its ends will be staked and their GPS coordinates (tolerance of ±1 foot) transferred to the spillway base map. Figure M13 of the Phase I Work Plan shows the general site access to the upstream area where the area of the proposed radar survey is located.

The survey will follow ASTM D5777-00 guidelines. Seismic waves will be generated by striking a 20-pound hammer on a metal plate lying on the ground. The waves will be sensed by 24 Mark Products model L-28 (28 Hz resonant frequency) geophones spaced 9 to 12 feet apart along the profile. Their signals will be recorded on a Geometrics R-48 digital seismograph. Data records will be made with the hammer source located at every 5th or 6th geophone (about 36 to 50 feet apart). The source will also be located about 60 to 80 feet off the end of each profile to increase estimated penetration to 50 to 65 feet.

The refraction data will be modeled with SEISIMAGER/R software. The first step in data reduction is to identify the first seismic wave arrival at each geophone from each hammer location. Arrivals are marked on the records and the time required for the wave traveling from the hammer (start of the record) to each geophone is measured. These times are plotted versus hammer-to-geophone distances. The data points are grouped into line segments representing subsurface velocity zones. Inverse slopes of these regression lines equal the zone's apparent velocities. True velocities and boundaries between velocity zones are modeled using the ray tracing and general reciprocal techniques.

Stratigraphy can be inferred from the velocity model and surface geological observations.

Vertical offsets in the bedrock velocity boundary and relatively low bedrock velocity zones will be highlighted and their locations and depths transferred to the spillway base map. Locations of areas where the bedrock is deep and alluvium is thicker that may be prone to erosion will also be transferred to the base map.

Summary Geophysical Report

At the completion of the geophysical tasks discussed above, a summary geophysical report will be prepared to describe field activities and the results of geophysical surveys. This summary report will be included as an Appendix of the Phase I Spillway Condition Assessment Report.

Task M-5: Engineering Evaluation

In this task, we will perform geotechnical and structural engineering evaluation, based on available documentation, of the apparent suitability and stability of the left and right spillway walls based on available material properties for the concrete, backfill and foundation materials, and use of an appropriate seismic coefficient for pseudostatic analysis.

Based on information gathered in Tasks M-1 through M-4, GENTERRA will assess potential for foundation material under the spillway slab to become saturated and identify reaches of the spillway that are suspected of being saturated. If GENTERRA cannot assess this issue using available information, then GENTERRA will recommend additional investigation in Phase II to address this issue.

As part of this task, we will also perform an engineering evaluation of the results of the Phase I field work as well as results of limited engineering analysis, and develop comments and recommendations.

Task M-6: Phase I Spillway Condition Assessment Report

In this task, GENTERRA will prepare a draft Phase I Spillway Condition Assessment Report which will include the following:

1. Introduction and Background – This section will provide a brief history of the project as well as a summary of activities performed for the project.
2. Results of Document Review – This section will provide key findings from the document review process as well as updated summary of known issues of concern related to the existing spillway structure and spillway channel.
3. Results of Field Evaluation and Non-Destructive Evaluation – This section will provide our approach for the field evaluation as well as our general observations of the conditions of the spillway structure and spillway channel and further comments on known issues. This section will also include the results of non-destructive evaluation of the spillway structure using Impact Echo Method.
4. Results of Geologic Reconnaissance and Surficial Mapping – This section will provide our approach for geologic reconnaissance and surficial mapping. This section will also include an updated site geologic map which will show key geologic features and information in and around the spillway structure and spillway channel, as well as around the suspected zone of Magalia Fault in the spillway channel.
5. Results of Geophysical Survey – This section will provide a summary of the geophysical survey work and results from that work for the project, key findings and their implications related to the safety of the spillway structure and spillway channel. The report from the geophysical survey subcontractor will be included in an appendix of this spillway condition assessment report.

6. Results of Engineering Evaluation – This section will provide our approach for the geotechnical and structural engineering evaluation as well as the parameters that were used for the engineering evaluation. It will also present the results of the engineering evaluation and comments and implications of the results from a dam safety perspective.
7. Conclusions – This section will provide a refined list of known issues of concern at the Magalia Dam Spillway as well as our conclusions based on the results of the Phase I work. We will rank the issues of concern based on their relative severity and potential effects on the performance of the spillway and the safety of the dam.
8. Recommendations – **In this section of the Phase I report, we will identify the recommended order of priority for addressing concerns and place the highest priority on the most worrisome items to be remediated before the next rainy season and in subsequent years.** An example is the need to remove vegetation and trees from the spillway channel as soon as possible, as well as to protect the downstream toe of the dam from erosion during spillway discharge.

   This section will also provide PID with our recommendations for Phase II work, if needed, and will include recommendations for conceptual alternatives for permanent or interim repairs.

The Phase I report will include Attachment A – DSOD Slides, Attachment B – Selected Photos of Phase I Work, Attachment C – List of Documents Reviewed as part of the Phase I Condition Assessment Report, and Attachment D – Site-Specific Health & Safety Plan (SSHSP).

The draft of the Phase I Spillway Condition Assessment Report will be submitted to PID for review and comment. Then, after the incorporation of revisions requested by PID, we would submit the revised draft of Phase I Condition Assessment Report to PID in the format required by the DSOD for their review and comment. Then, after the incorporation of any revisions requested by DSOD, we would submit the final Phase I Spillway Condition Assessment Report to PID and DSOD. We will conduct discussions and coordination with PID and DSOD throughout the review of this Phase I Spillway Condition Assessment Report.

Task M-7: Project Management, Review & Discussion with PID & DSOD

In this task, we will provide management and coordination of Tasks M-1 through M-6 and will conduct meetings, teleconferences, discussions and communications with PID and DSOD to expedite the review process as well as to provide answers to questions and comments to complete the Phase I work in a timely manner.

Task M-8: Phase II Work Plan, if needed

In this task, we will develop the Phase II Work Plan, if needed. The draft of this Phase II Work Plan will be submitted to PID for review and comments. Then, after the incorporation of any revisions requested by PID, we would submit the revised draft of the Phase II Work Plan for submittal to DSOD for review and comment. Then, after the incorporation of any revisions requested by DSOD, we would submit the final Phase II Work Plan to PID and DSOD for review and approval of the Phase II Work Plan. We will conduct discussions and coordination with the DSOD throughout the review of this Phase II Work Plan.

E.4 Methods and Equipment to be used in Phase I for Magalia Dam Spillway

The following equipment will be used in the Phase I work to address some of the issues summarized in Section 3 of the approved Work Plan as well as other items to provide a comprehensive spillway condition assessment. Please see Section 5.4.4 of the Phase I Work Plan and the text for Task M-4 above for the descriptions of the Geophysical Surveys to be performed. Presented below are details of the geophysical equipment to be used:

Ground Penetrating Radar (GPR) Survey

Geophysical Survey Systems Model SIR-3000 GPR

Antenna frequencies of 400, 500, 900, and 1600 MHz with data transferred to a PC

GSSI RADAN processing software to develop a 3-D model by combining all survey profiles

Multi-Channel Analysis of Surface Waves (MASW) Survey

A 20-pound hammer to strike a metal plate thereby generating seismic waves

Mark Products Model L-4 geophones to sense the seismic waves

Geometrics R-48 digital seismograph to record the signals

SEISIMAGER software to model each MASW sounding

Seismic Refraction Survey

A 20-pound hammer to strike a metal plate thereby generating seismic waves

24 Mark Products Model L-28 geophones to sense the seismic waves

Geometrics R-48 digital seismograph to record the signals

SEISIMAGER/R software to model the refraction data

Impact Echo Instrument Readings

Concrete Thickness Gauge, Model CTG-2

PC with Olson's WinCTG2 software for data acquisition and analysis

Additional Equipment

Hammer, chain, plumb bob, 4-foot level, camera, ruler, 100-foot measuring tape, surveying equipment, flash light, 12-foot long No. 6 reinforcing steel rod for probing, and other small tools as necessary

E.5 Project Site Access for Magalia Dam Spillway

The general access to the upstream area and downstream area are shown on Figures M13 and M14 in the Phase I Work Plan. These access maps may be updated based on our field evaluation in Task M-2.

GENTERRA will install anchor points at key locations for use during our field evaluation described in the approved Work Plan as well as for use by the District and DSOD personnel during future field evaluations. Prior to site access, all personnel will go through our Site-Specific Health and Safety Plan (SSHSP) that is discussed below.

E.6 Site-Specific Health and Safety Plan for Magalia Dam Spillway

All personnel who will be on-site to execute the work that is described in the approved Work Plan will read and understand the Site-Specific Health and Safety Plan (SSHSP) before the start of the field work. In addition, daily safety meetings will be held at the project site, and personnel will be provided to assist in real-time review of the safety practices implemented throughout the field work.

A Site-Specific Health and Safety Plan (SSHSP) has been prepared by GENTERRA to perform geophysical and exploratory drilling operations prior to mobilizing for the work. Specifics of the SSHSP implementation will be coordinated between PID and GENTERRA, and the geophysical subcontractor. A final version of the SSHSP is attached to the Phase I Work Plan as Attachment D.

E.7 Items to be provided by PID for Magalia Dam Spillway

E.7.1 Topographic Map of Magalia Dam Spillway

Due to time limitations to complete the work described in the Work Plan, GENTERRA proposes to use existing topographic mapping of the dam, spillway, and nearby surrounding areas for use in the geologic reconnaissance and eventual plotting of data for inclusion in the Phase I report.

PID may want to consider performing an updated topographic survey for use in future work to have more accurate data of the existing topography.

E.7.2 Access Ladders for Magalia Dam Spillway

As part of our field work, GENTERRA will install anchor points at key locations for use during our field evaluation described in the approved Work Plan as well as for use by PID and DSOD personnel during future field evaluations. During our field evaluation in Task M-2, we will identify the locations where access ladders may be needed during the field work discussed in this project as well as for use by PID and DSOD personnel during future field evaluations. If needed, we will work with PID to identify the correct ladder type and anchor points for the ladders so that ladder will be stable during use. We have assumed that PID will purchase the ladders, if needed.

E.8 Environmental Disturbances and Mitigation Measures for Magalia Dam Spillway

Figure M1 of the Phase I Work Plan provides a view of the anticipated area to be utilized during the field work as described in the approved Work Plan. The actual work to be performed will be on the spillway structure, spillway channel and slopes and along the upstream slope of the dam. The following table lists potential disturbances during the field program, environmental impacts, and the planned mitigation measures where applicable to avoid any safety issues.

TABLE 5-1	
Potential Disturbance	**Remarks / Mitigation Measures**
General Access to the spillway area and portions of the dam.	Minimize disturbance by using existing path(s). Most work will be performed while walking on the ground and concrete surfaces and with fall protection and rope access, where needed. No excavation will be performed during the proposed work and we will not disturb existing environmental features during our field work

E.9 Project Schedule for Magalia Dam Spillway

The duration of the Phase I work as described in Tasks M-1 through M-8 in the previous sections is anticipated to have a total duration of approximately 4 months. The duration of the field work is expected to be a maximum of two to three weeks. During the field work, a seven-day work week will be utilized during the field evaluation, and the normal working hours are assumed to be from 7:00 A.M. until 5:30 P.M. Extended hours may be warranted on a special case scenario depending on the status of the individual tasks being performed. Representatives of GENTERRA and our Geophysics Subcontractor will be present during the field program to provide oversight of the field work. At least one representative from GENTERRA will be on-site at any given time during proposed field work. Not all personnel will be represented at all times.

SECTION F. SPECIFIC APPROACH & SCOPE FOR PARADISE DAM SPILLWAY

F.1 Specific Approach for Paradise Dam Spillway

The following work is included in the Phase I Work Plan for the Paradise Dam spillway to address Issues No. 1 through 10 that are listed and described in Section 3 of the approved Phase I Work Plan, as well as any other identified items, to provide a comprehensive spillway condition assessment.

All of the proposed tasks for Paradise Dam will be performed consistent with the approved Phase I Work Plan. The Phase I Spillway Condition Assessment will be valuable to tailor the assessment and possibly avoid a Phase II site investigation and for development of tailored cost-effective Phase II site investigation and field testing programs in a credible and cost-effective manner.

In the Phase I Work Plan, we describe our plans to perform a careful visual examination and develop a focused photographic record, and confirming that we will take necessary measurements and perform some limited non-destructive field testing and sounding of concrete using hammers, our special chain device to detect delamination of concrete, and our portable geophysical instrument to make an initial assessment of any potential damage, delamination, voids, cracks, etc. We also describe other geophysical surveys and non-destructive testing to be performed in Phase I by GENTERRA's geophysics subcontractor. The Phase I Work Plan also describes our planned evaluation of the conditions of weep holes and drains, and their locations. It is important to note that the Phase I Spillway Condition Assessment will be valuable to tailor the assessment and possibly avoid a Phase II site investigation and for development of tailored cost-effective Phase II site investigation and field testing programs in a credible and cost-effective manner.

The planned Phase I work includes the steps needed to evaluate the current conditions of the distressed areas (or potentially distressed area or potential to have undetected distress or potential to have future distress) of the spillway, the likely cause(s) of the damage to the spillway, and commence consideration of potential remedial measures for the damaged areas of the spillway (if needed), together with a ranking of the relative importance and potential scheduling of those remedial measures.

Based on the results of the Phase I work, additional field investigation may be needed as Phase II, and would be described in more detail when it is developed after completion of Phase I.

The proposed Phase I Spillway Condition Assessment includes the following steps:

- Review available documents and issues in this report;
- Perform a visual inspection to document the extent and severity of any distress or deterioration on the spillway structures;
- Inspect weep holes and subdrain systems for functionality, silt and vegetative growth;
- Obtain measurements of the approximate extents of the distressed and delaminated areas;

- Develop a detailed photographic record of the distressed portions of the spillway and the surrounding area;
- Conduct a detailed visual inspection of the spillway slab documenting locations of irregularities and weaknesses that could affect flow resulting in cavitation. We will document locations on drawings and obtain photographs;
- Use the "chain drag" method to identify the extents of delaminated portions of the spillway;
- Perform hammer sounding testing to supplement the chain drag method and to identify the extent of delaminated portions of the spillway;
- Mark the extent of the estimated limits of delamination and distressed areas using white marking paint;
- Perform geophysical surveys to measure the thickness and integrity of the concrete in the spillway slab and walls using GENTERRA's Impact Echo instrument;
- Perform geophysical non-destructive surveys of the spillway and the adjacent areas to determine concrete conditions, subgrade conditions and subsurface groundwater profiles. These procedures will include the following methods: GPR Survey, Electrical Resistivity Survey, Seismic Refraction Survey, and Impact Echo Testing;
- Perform a geologic reconnaissance and delineation of features, especially for any discontinuities, fractures, faults, and other geologic features along the spillway channel;
- Evaluate results of the Phase I field work and develop comments and recommendations; and,
- Prepare a Phase I Spillway Condition Assessment Report with a Phase II Work Plan (if needed).

F.2 Objectives of Field Work in Phase I

The following items regarding the spillway slab will be investigated:

- Determine the concrete slab thickness using GPR and Impact Echo testing;
- Determine the condition of the concrete in the slab and walls using Impact Echo testing;
- Investigate if there are voids beneath the spillway slab and/or backfill concrete using GPR;
- Determine the location, spacing, and bar size of reinforcing steel in the slab using GPR;
- Determine if steel anchor bars exist to anchor the slab to the foundation using GPR; and,

Determine existing delamination of the spillway slab by dragging a specially-fabricated chain device over the surface of the spillway slab.

Using the results of the above investigation, we will prepare a composite drawing showing all locations of anomalies and slab details such as thickness, reinforcement, and anchors.

Evaluate spillway drains:

Drains for the flip bucket are plugged. Use a probe to clear the drains and determine the cause of clogging.

Map the drains beneath the slab and along the spillway walls using GPR.

Assess the functionality of the drains using a portable video camera or other portable equipment. Map locations where drains are clogged or damaged.

Investigate the high groundwater condition at the left abutment:

Use electrical methods to map springs and determine the groundwater regime in this area.

Determine the source of flow coming through joints in the floor slab and left wall of the spillway.

Evaluation of rock erodibility:

This evaluation will be made by visual observations of discontinuities in the rock and their orientations.

F.3 Proposed Tasks of Phase I Work Plan for Paradise Dam Spillway

Task P-1: Document Acquisition and Review

In this task, GENTERRA will visit the offices of the DSOD located in Sacramento, California to obtain internal DSOD documents such as reports, photos, memoranda and correspondence that were prepared by DSOD after 2002, which was the year in which document acquistion was previously done by GENTERRA for PID. As related to PID's files, we have already received electronic files of pertinent plans, reports, photos, DSOD communications, and other pertinent data related to the design and construction of the dam, as well as any identified conditions or concerns, changes or upgrades made to the dam. During the DSOD visit, as necessary, we will ask questions of the assigned DSOD personnel regarding any additional or new information related to the subject project or as learned from similar projects. During the visit to DSOD, or in separate discussions by phone or Email, we will discuss with DSOD representatives regarding their expectations for remedial repair. We will also discuss with the DSOD and PID any other issues identified in the files that are related to the spillway structure.

Electronic copies will be made of pertinent documents from the DSOD for our use in the evaluation and for submittal to PID for inclusion in their files for the dam. The extent of the files designated for reproduction will be determined with PID concurrence once GENTERRA identifies the files and obtains a cost estimate from the DSOD-approved reproduction company. These files will be used by GENTERRA personnel in document review to be performed in this task.

A preliminary list of the documents to be reviewed in this task was presented below and is also presented in Attachment C of the approved Phase I Work Plan. During our review, attention will be paid to known issues that were discussed in Section 3 of the Work Plan as well as to any other issues that may be of concern to the safety of the dam and spillway.

1) Construction Documents
    - As-Built Plans
    - Construction Specifications
    - Construction Reports
    - Reconstruction Reports, Plans and Specifications
2) Technical Documents from GENTERRA Files and Other Sources
    - Engineering Reports
    - Geologic Reports
3) Annual Dam Safety Surveillance Reports
    - Annual Dam Safety Surveillance Reports by GENTERRA
    - Annual Dam Safety Surveillance Reports by Others
4) Inspection Reports
    - Inspection Reports by GENTERRA
    - Inspection Reports by DSOD
    - Inspection Reports by Others
5) Repair and Maintenance Records
    - Repair and Maintenance records by PID
    - Repair and Maintenance records by Others
6) Photographs
    - Photographs Taken During Construction
    - Photographs Taken During Inspections by GENTERRA
    - Photographs Taken During Inspections by DSOD
    - Photographs Taken During Inspections by Others
7) PowerPoint Presentation Slides used by DSOD During the Meeting held on July 6, 2017 amongst DSOD, PID, and GENTERRA and Notes Taken During Meeting by Joseph J. Kulikowski of GENTERRA
8) Documents from DSOD Files
    - Additional Documents will be acquired from DSOD Files during Phase I
9) Other Documents from PID Files and Other Sources

Task P-2: Field Evaluation and Non-Destructive Evaluation

GENTERRA personnel will perform the field evaluation task after completion of the review of the available pertinent documents. We will notify DSOD of our field evaluation schedule at least 72 hours in advance so that DSOD personnel can also participate in the field evaluation to be performed.

In this task, key GENTERRA team professionals will visit the site of the spillway structure and spillway channel with personnel from PID to visually observe conditions and to gather available site data. The following individuals are expected to participate in the site visit: Joseph J. Kulikowski, P.E., G.E. (Principal-In-Charge/Project Manager); Soma Balachandran, Ph.D., P.E., G.E. (Principal Engineer/Geotechnical Engineer); Michael Wolff, P.G., C.E.G. Principal Engineering Geologist; Chuck Hutton, P.E, Principal Structural Engineer; and J. Will Kulikowski (Field Technician). The main purposes of the site visit are to gain a visual understanding of the extent of the existing damage/distress, visual condition of the existing spillway structure and spillway channel, and to verify and refine information on access for field work that is presented in the approved Work Plan. Site constraints and operational limitations that could affect the condition assessment discussed in the approved Work Plan and construction access for repair work, means and methods to perform will also be evaluated during the site visit.

During the site visit for field evaluation, GENTERRA will perform a detailed inspection of the conditions of all transverse and longitudinal joints, including but not limited to offset, opening, slab tilting, bulging, edge spalling, and potential for water to flow through joints. GENTERRA will also perform hammer sounding at accessible locations in and around the existing damage for signs of concrete delamination. Since the spillway crest area is relatively level, we should be able to access the distressed area of the spillway structure in a safe manner. While surface testing results are not comprehensive, hammer testing is considered good practice to accompany visual observation and could assist in refining the work discussed in the approved Work Plan. In this site visit, we will attempt and apply other techniques, such as chain dragging, to obtain information regarding concrete delamination. We will also use GENTERRA's Impact Echo instrument to evaluate the thickness and integrity of the concrete at selective locations.

This field evaluation will enable GENTERRA representatives to become familiar with the existing structural features, configuration, and overall condition of the spillway structure. We believe that early detection of even small problems can result in significant reduction of future operational and maintenance costs.

During this site visit, we will interview PID's maintenance representative to assess whether routine maintenance and minor repair procedures are adequate or need improvement. Based on that information, GENTERRA may suggest to PID any feasible improvements to routine maintenance and repair procedures.

Based on our field evaluation, GENTERRA may refine the field work that is discussed in Tasks P-3 and P-4 in the Phase I Work Plan. Any needed refinement to the field work will be discussed with PID and DSOD before implementation of such change during the field work. Any needed change(s)/refinement(s) will be communicated in a timely manner to PID and DSOD to avoid any delay in the field work activities.

The following discussion is provided to supplement the details in the Phase I Work Plan and to explain why it is important for an experienced structural engineer, an experienced geotechnical engineer and an experienced engineering geologist to participate in the field evaluation in the Phase I activities.

In order to perform a proper and complete concrete condition assessment, the structural engineer should participate in the Phase I site visit and visual inspection to personally observe, map and record the nature and extent of concrete cracks, spalls and other deterioration. A visual inspection of the exposed concrete by the structural engineer is the first step in an on-site examination of a structure. Visual inspection is one of the most versatile and powerful NDT methods. However, its effectiveness depends on the knowledge and experience of the investigator. The purpose of such an examination is to locate and define areas of distress or deterioration. It is important that the conditions observed be described in unambiguous terms that can later be understood by others who have not inspected the concrete. The results from the Phase I on-site inspection and evaluations will be used to prepare the plan for any required Phase II investigations. In addition, the hammer sounding and chain dragging should be performed in the presence of (or personally by) a structural engineer with previous experience in conducting these investigations. A trained and experienced ear is required to evaluate the results from these tests.

An experienced geotechnical engineer and an experienced engineering geologist will provide valuable input for the subject. While the structural engineer can identify existing issues, input from the geotechnical engineer and an engineering geologist is very vital to understand the underlying causes related to the some of the observed distress in concrete. When it comes to evaluating unprotected spillway channel, it will be the responsibilities of a geotechnical engineer and an engineering geologist. In any project, an engineering geologist and a geotechnical engineer develop recommendations for the structural engineer by studying the local geology and by evaluating the subsurface properties. Without properly understanding the history of the project site and knowing the engineering properties of the subsurface materials, a structure cannot be properly designed and constructed.

All in all, a team consisting of an experienced geotechnical engineer, an experienced engineering geologist, and an experienced structural engineer is very important for the subject project to identify the causes for observed distress and to develop cost-effective remedial measures.

Task P-3: Geologic Reconnaissance and Surficial Mapping

As the first step of this task, an Engineering Geologist will characterize the geologic and seismic setting of the site based on existing information and information that will be gathered in this task by conducting an initial review of published geological literature, USGS/California Geological Survey (CGS) maps, regional geologic maps, and other geotechnical data pertinent to the site, including the documents that are listed in Attachment C.

Available aerial photography will be obtained and analyzed for evidence of photolineaments that may be related to underlying geologic structures, including faults. In addition, aerial photos will be analyzed for signs of existing or potential slope instability. Any suspect features identified in the aerial photo analysis will be flagged for field examination in the geologic reconnaissance activity. Surficial geologic mapping will be performed to validate and update existing site geologic map.

We will notify DSOD of our field work schedule related to the geologic reconnaissance and surficial geologic mapping at least 72 hours in advance so that DSOD personnel can also participate in the field evaluation to be performed.

The geologic mapping will focus on the following issues:

- Geologic conditions adjacent to the spillway structure;
- Faulting;
- Discontinuities in exposed bedrock along the spillway channel; and,
- Information needed for erodibility studies, such as joint spacing, orientation, degree of jointing or fracture in a rock mass, etc.

As part of this task, an updated site geologic map will be prepared for use in the Phase I Spillway Condition Assessment as well as to refine the planned geophysical work discussed below.

The following discussion is provided to supplement the details in the Phase I Work Plan and to explain why it is important for an experienced engineering geologist to participate in the field evaluation in the Phase I activities.

A visual inspection of all of the observable geologic features will be critical to developing an integrated technical understanding of the fundamental role that geologic processes play in exacerbating or mitigating observed issues affecting the safety and performance of the spillway. Such observations will enable optimization of the planned geophysical work in Phase I, and will also benefit the selection of any required Phase II invasive studies such as fault trenching or piezometer installation should such activities be warranted and recommended for Phase II. In Phase I, the engineering geologist will personally record key geologic metrics such as apparent rock quality designation (RQD), rock discontinuity orientations, shear zone characteristics, and groundwater seepage zones, to name but a few. The geologist will personally take photographs of observed features for later study and incorporation on maps and other project record documents. By observing features and collecting data first hand, the engineering geologist will be able to apply his wealth of experience to optimize the value realized in the important first phase of the work.

Task P-4: Geophysical Survey

Detailed Descriptions of Geophysical Surveys for Specific Issues

The Phase I Spillway Condition Assessment will include NDT geophysical surveys to address the stated concerns/issues regarding the spillway slabs and walls and subgrade conditions, as well as the high groundwater in the left abutment and the potential for erosion during spillway flows. ACI 228.2R-13 (2013) recommends and describes how to apply the appropriate methods for the issues that were presented in Section 3 of the approved Work Plan. Geophysical surveys will be conducted in accordance with ASTM standards. Results will be correlated with available geotechnical, geological, and hydrology information to quantify problem areas and establish their lateral and vertical extent possibly for further investigation in Phase II, if necessary.

Presented in this Section are details of the geophysical methodologies and equipment to be used specifically for Issues Numbers 1 through 11 listed and described in Section 3 of the approved Phase I Work Plan.

Proposed Phase I Geophysics Survey for Issues Nos. 2, 3 and 6 – Groundwater in Left Abutment Area

A two-dimensional electrical resistivity cross section could be completed in the soil adjacent to the spillway left wall to delineate groundwater conditions from possible springs in the left abutment down to the area next to the Flip Bucket. The cross section may show where groundwater is flowing beneath the spillway floor which may cause erosion and settlement.

Suspected springs in the left abutment may be responsible for shallow groundwater that is flowing in the spillway through joints and weep holes. It also may the source of the water flowing down the slope adjacent to the spillway (Attachment B Photographs P2-1 through P2-13, P3-1 through P3-12, and P6-1 through P6-7, all located in the Phase I Work Plan). As part of the geological mapping of the springs, an electrical resistivity profile may detect the springs and shallow ground flow towards and under the spillway. The resistivity results could help optimally position borings and piezometers to gauge groundwater flow.

Groundwater within soils and bedrock generally reduces electrical resistivity that can be detected with surface measurements. Figure P4 is a cross section showing lateral and vertical variations of resistivities along a fractured bedrock ridge. The very low resistivity zones (blue) corresponded with visual springs. Groundwater flow was estimated from the low to medium resistivity trends.

Figure P5 of the Phase I Work Plan shows the proposed electrical resistivity survey alignment along the left side of the spillway where the springs are suspected and a stream of water is flowing at the surface. ***Figure P6 of the Phase I Work Plan shows the proposed electrical resistivity survey alignment along the right side of the spillway where the springs are suspected to travel underneath the spillway slab and merge into the right side of the spillway. Please note that in order to reduce the cost for Phase I investigation, the electrical resistivity survey alignment along the right side of the spillway will not be performed. If it is required later, it can be included in the Phase II Work Plan, but we believe that we can perform the assessment without it***. The profile will be 500 to 550 feet long. Its ends will be staked and their GPS coordinates (tolerance of ±1 foot) transferred to the spillway base map. Figure P12 of the Phase I Work Plan shows the general site access to the upstream and downstream areas.

The survey will follow ASTM D6431-99 guidelines. Metal stake electrodes spaced 9 to 12 feet apart will be hammered into the ground and connected together with a multi-connector cable. One-gallon water buckets with saltwater will be placed at each electrode to keep the soil moisture so contact resistance with the metal rod is kept at a minimum. Electrode elevations will be measured with a Pentax PTS-III-10 total station (tolerance of ±0.5 feet). The cable will be attached to an AGI Super Sting R56 instrument. Data will be recorded using the standard Schlumberger, dipole-dipole, and possibly the pole-dipole electrode arrays. Penetration will be 60 to 80 feet.

The resistivity data will be modeled with EARTHIMAGER-2D software. For each raw data point, an apparent resistivity value will be calculated using the geometry of the two current and two potential electrodes, amplitude of the injected electrical current, and the measured voltage of the electric field generated in the ground. A finite element mesh will be generated between the data points. Initially, mesh points are assigned the raw apparent resistivity values and a smoothed resistivity model cross section is calculated. Synthetic data values at the mesh points are then calculated from the resultant resistivity model. The resistivity model is updated by comparing the mismatch between synthetic data and recorded data and another iteration round is completed. This process continues until the synthetic and recorded data statistically match within an acceptable tolerance (usually less than 7%).

Each separate array data set will be model independently. Then, the composite data set of all three arrays will be modeled and compared to the individual array results to ensure all features of the final models were caused by the data and were not processing artifacts.

Stratigraphy and hydrology can be inferred from the resistivity model and surface geological observations. Relatively low resistivity zones that may represent shallow groundwater will be highlighted and their locations and depths transferred to the spillway base map.

Proposed Phase I Geophysics Survey for Issues Nos. 5 and 7 – Restricted Subdrain Flow and Potential Erosion

A radar survey on the spillway floor could detect the 6-inch subdrain pipe which could influence water flow beneath the concrete.

There is concern about potential undercutting of the spillway floor (550 feet NE x 20-70 feet NW and walls (Attachment B Photographs P5-1 through P5-9 and P7-1 through P7-8, all located in the

Phase I Work Plan). Characterizing the concrete's condition could include detection of air and water filled voids, pipes, rebar (and more importantly missing rebar), and structural elements. Subgrade drains, erosion areas, and possibly shallow saturation zones in the underlying soils could also affect concrete stability.

All these features have distinctly different dielectric values that can be detected by a ground penetration radar survey. ACI recommends radar for investigating concrete structures. The literature lists dielectric values (this quantity has no dimensions) for concrete in the range of 7 to 11. The features of interest have measurably different values, air filled void (1), metal objects (very high), water filled void (81), dry sandy soil (3-5), and saturated sandy soil (25-30), so they form recognizable anomalies relative to the concrete. Radar data (Figure P7 of the Phase I Work Plan) can detect vertical and lateral dielectric changes as an antenna is pulled along a profile.

Figure P8 of the Phase I Work Plan shows the proposed radar survey alignment recommended for Phase I. A series of parallel, northeast oriented profiles that extend across the entire spillway floor and along both walls could delineate the conditions of concern. A data sampling rate of 40 to 60 data scans per foot will provide adequate vertical resolution to detect small dimension features. Profiles are oriented along the spillway long axis for recording efficiency and safety reasons.

On the floor, the first profile will be as close to the left wall as possible and the last will be as close to the right wall as possible while keeping the profiles straight and parallel (crooked profiles cannot be processed properly). Additional profiles will be located 3 and 7 feet from both walls to increase the lateral resolution near the walls' footings. On the walls, profiles will be as close to the floor as possible and then 2, 3, and 4 feet above the floors.

Profile ends will be painted on the concrete and their GPS coordinates (tolerance of ±1 foot) transferred to the spillway base map. Site access could be from the spillway northeast end.

Measurements will be made with a Geophysical Survey Systems model SIR-3000 ground penetrating radar. The system consists of a digital recorder mounted on a cart and a shielded, down-looking antenna. The system sends EM waves from the antenna into the concrete and underlying soil and rock. These waves partially reflect at boundaries between materials with different dielectric properties. The reflected waves are measured by the same surface antenna, digitally stored, and displayed.

Data recording and processing procedures will follow ASTM 6432-11 and 4748-10 guidelines. The most critical measurement parameter for this survey is the choice of antenna frequency. Higher frequency antenna provides higher spatial resolution of subsurface features because the signal's wavelength is smaller. However, the earth acts as an efficient high-cut electrical filter and greatly attenuates the propagation of high frequency EM waves. Penetration decreases at higher frequency because there is more attenuation by the earth's filter. Before production data recording starts, feasibility tests will be conducted at one or two locations on the concrete. Data will be recorded with 400, 500, 900, and 1600 MHz antennas. Real time interpretation will determine the optimum frequency that can resolve the conditions of concern while providing adequate penetration of at least two feet into the underlying soil or rock.

During the production survey, the distance measuring odometer will be calibrated twice along a 30- to 50-foot measuring tape to ensure the recorded distances along the profile are recorded. The optimum frequency antenna will be manually moved by the operator along one profile at a time. Great care will be taken to keep the antenna traveling in a straight line along each profile that will be temporary marked with a rope or measuring tape. Each profile will be saved as an independent data file. In Phase II, concrete thickness will be directly measured in five, one-inch-diameter core holes drilled with an impact hammer drill. These core holes will be randomly located selected data profiles and their locations posted on the base map.

Data will be transferred to PC and all the standard geometry processing corrections applied using GSSI RADAN software. After obtaining concrete thickness in Phase II, concrete dielectric values will be iteratively modeled at each core hole so the radar anomaly thickness will match the concrete thickness as actually measured. Final dielectric values will be added to all data files. A three-dimensional model will be developed by combining all profiles into one grid for the floor and for both walls. The finished model can display radar anomalies interpreted as subsurface features; the final radar model is a three-dimensional cube with northing, easting, and depth (or elevation) axes. Within the software, a vertical slice of radar data can be exported which will look similar to a cross-section. Also, a flat surface at any depth (or at a particular elevation) can be exported that will look like a contour map of radar signal amplitude. Report figures will be constructed from different sections and depth surfaces chosen to highlight features of interests (rebar spacing, concrete depth, air filled voids).

Concrete thickness can be displayed as a depth contour map on top of the base map. Locations of features within and beneath the concrete will be measured from the model and added to the base map.

Proposed Phase I Geophysics Survey for Issues Nos. 7 and 8 – Potential Erosion and Concrete Condition and Integrity

Two-dimensional seismic refraction profiles in the soil adjacent to the spillway left wall could delineate bedrock depth and topography. Thicker backfill in deep bedrock areas may cause subsidence that is responsible for concrete floor cracking. By carefully designing the refraction array, subtle changes in bedrock velocity and topography offsets may delineate fault zones. Adding MASW soundings at suspected subsidence areas and maybe at the cracks near the spillway end would determine the shear velocity that could be combined with the refraction compressional velocities to estimate bedrock elastic moduli.

There may be soil features and bedrock discontinuities near the spillway that raise concerns about potential erosion (Attachment B Photographs P7-1 through P7-8 and P8-1 through P8-7, all located in the Phase I Work Plan). As part of the geological mapping of the shear zones near the spillway bottom, a seismic refraction profile may detect the shear zones, the boundary between ultrabasic and calc-silicate units, and deep bedrock where the alluvium is thicker and may be prone to erosion.

Shear zones within the bedrock and boundaries between rock types may cause changes in compressional wave velocities that can be detected with surface measurements. Figure P9 of the Phase I Work Plan is a refraction survey cross section showing lateral and vertical variations of three distinct compressional velocity zones. The upper two zones represent alluvium with varying degrees of compaction. The deeper bedrock velocity shows a relative lower velocity zone associated with fault shearing.

Figures P10 and P11 of the Phase I Work Plan show the proposed seismic refraction survey alignments that are roughly perpendicular to the shear zones and the ultramafic and calc-silicate boundary and is located along a service road about 20 feet west of and about 5 feet east of the spillway where access is better. ***Please note that in order to reduce the cost for the Phase I investigation, the seismic refraction survey along the right side of the spillway will not be performed. If it is determined as necessary, it can be included in the Phase II Work Plan, but at this time we believe that we can perform the assessment without it.*** The profile will be 500 to 550 feet long. Its ends will be staked and their GPS coordinates (tolerance of ±1 foot) transferred to the spillway base map. Figure P12 of the Phase I Work Plan shows the general site access to the upstream and downstream areas.

The survey will follow ASTM D5777-00 guidelines. Seismic waves will be generated by striking a 20-pound hammer on a metal plate lying on the ground. The waves will be sensed by two spreads of 24 Mark Products model L-28 (28 Hz resonant frequency) arranged end-to-end. Geophones will be spaced 9 to12 feet apart along each geophone spread. Their signals will be recorded on a Geometrics R-48 digital seismograph. Data records will be made with the hammer source located at every 5th or 6th geophone (about 36-50 feet apart). The source will also be located about 60 to 80 feet off each geophone spread end to increase estimated penetration to 50 to 65 feet.

The refraction data will be modeled with SEISIMAGER/R software. The first step in data reduction is to identify the first seismic wave arrival at each geophone from each hammer location. Arrivals are marked on the records and the time required for the wave traveling from the hammer (start of the record) to each geophone is measured. These times are plotted versus hammer-to-geophone distances. The data points are grouped into line segments representing subsurface velocity zones. Inverse slopes of these regression lines equal the zone's apparent velocities. True velocities and boundaries between velocity zones are modeled using the ray tracing and general reciprocal techniques.

Stratigraphy can be inferred from the velocity model and surface geological observations. Relatively low bedrock velocity zones that may represent the shear zones and lateral bedrock velocity changes possibly caused by the ultrabasic and calc-silicate boundary will be highlighted and their locations and depths transferred to the spillway base map. Location of areas where the bedrock is deep and alluvium is thicker that may be prone to erosion will also be transferred to the base map.

A gridded radar survey across both the entire spillway floor and possibly walls, or only at identified problem locations could delineate many conditions. It could map the rebar and other structural members and pipes in the concrete. It could delineate voids (air-filled and water filled) in the concrete and the underlying soils. It could determine concrete thickness and possibly crack locations and depth.

This would be in conjunction with the other components of the Phase I field work, including the hammer sounding and Echo Impact Instrument.

Summary Report

At the completion of the geophysical tasks discussed above, a summary report will be prepared to describe field activities and the results of geophysical surveys. This summary report will be included as an Appendix of the Phase I Spillway Condition Assessment Report.

Task P-5: Engineering Evaluation

In this task, we will perform geotechnical and structural engineering evaluation, based on available documentation, of the apparent integrity and stability of the spillway walls based on available material properties for the concrete, backfill and foundation materials, and use of an appropriate seismic coefficient for pseudostatic analysis

Based on information gathered in Tasks P-1 through P-4, GENTERRA will assess the potential for foundation material under the spillway slab to become saturated and identify reaches of the spillway that are suspected of being saturated. If GENTERRA cannot assess this issue using available information, then GENTERRA will recommend additional investigation in Phase II to address this issue.

GENTERRA will also assess the effects of the tree roots on the drainage system of the spillway and will develop necessary recommendations to mitigate or to reduce such impacts to the spillway structure. As part of this task, we will also perform an engineering evaluation of the results of the Phase I field work as well as results of limited engineering analysis and develop comments and recommendations.

Task P-6: Phase I Spillway Condition Assessment Report

In this task, GENTERRA will prepare a draft Phase I Spillway Condition Assessment Report which will include the following:

1. Introduction and Background – This section will provide a brief history of the project as well as a summary of activities performed for the project.
2. Results of Document Review – This section will provide key findings from the document review process as well as updated summary of known issues of concern related to the existing spillway structure and spillway channel.

3. Results of Field Evaluation and Non-Destructive Evaluation – This section will provide our approach for the field evaluation as well as our general observations of the conditions of the spillway structure and spillway channel and further comments on known issues. This section will also include the results of non-destructive evaluation of the spillway structure using Impact Echo Method.
4. Results of Geologic Reconnaissance and Surficial Mapping – This section will provide our approach for geologic reconnaissance and surficial mapping. This section will also include an updated site geologic map which will show key geologic features and information in and around the spillway structure and spillway channel.
5. Results of Geophysical Survey – This section will provide a summary of the geophysical survey work and results from that work for the project, key findings and their implications related to the safety of the spillway structure and spillway channel. The report from the geophysical survey subcontractor will be included in an appendix of this spillway condition assessment report.
6. Results of Engineering Evaluation – This section will provide our approach for the geotechnical and structural engineering evaluation as well as the parameters that were used for the engineering evaluation. It will also present the results of the engineering evaluation and comments and implications of the results from a dam safety perspective.
7. Conclusions – This section will provide a refined list of known issues of concern at the Paradise Dam Spillway as well as our conclusions based on the results of the Phase I work. We will rank the issues of concern based on their relative severity and potential effects on the performance of the spillway and the safety of the dam.
8. Recommendations – **In this section of the Phase I report, we will identify the recommended order of priority for addressing concerns and place the highest priority on the most worrisome items to be remediated before the next rainy season and in subsequent years.** An example is the need to remove vegetation from the spillway channel as soon as possible, as well as to improve the drainage system to reduce uplift pressures on the spillway structure.

   This section will provide PID with our recommendations for Phase II work, if needed, and will include recommendations for conceptual alternatives for permanent or interim repairs.

We will include Attachment A – DSOD Slides, Attachment B – Selected Photos of Phase I Work, Attachment C – List of Documents Reviewed as part of the Phase I Condition Assessment Report, and Attachment D – Site-Specific Health & Safety Plan (SSHSP).

The draft of the Phase I Spillway Condition Assessment Report will be submitted to PID for review and comment. Then, after the incorporation of revisions requested by PID, we would submit the revised draft of Phase I Condition Assessment Report to PID in the format required by the DSOD for their review and comment. Then, after the incorporation of any revisions requested by DSOD, we would submit the final Phase I Spillway Condition Assessment Report to PID and DSOD. We will conduct discussions and coordination with PID and DSOD throughout the review of this Phase I Spillway Condition Assessment Report.

Task P-7: Project Management, Review and Discussion with PID & DSOD

In this task, we will provide management and coordination of Tasks P-1 through P-6 and will conduct meetings, teleconferences, discussions and communications with PID and DSOD to expedite the review process as well as to provide answers to questions and comments to complete the Phase I work in a timely manner.

Task P-8: Phase II Work Plan, if needed

In this task, we will develop the Phase II Work Plan, if needed. The draft of this Phase II Work Plan will be submitted to PID for review and comments. Then, after the incorporation of any revisions requested by PID, we would submit the revised draft of the Phase II Work Plan for submittal to DSOD for review and comment. Then, after the incorporation of any revisions requested by DSOD, we would submit the final Phase II Work Plan to PID and DSOD for review and approval of the Phase II Work Plan. We will conduct discussions and coordination with the DSOD throughout the review of this Phase II Work Plan.

F.4 Methods and Equipment to be used in Phase I for Paradise Dam Spillway

The following equipment will be used in the Phase I Site Investigation to address some of the issues summarized in Section 3 of the approved Phase I Work Plan as well as other items to provide a comprehensive spillway condition assessment. Please see the text above for Task P-4 and also in Section 5.4 in the approved Phase I Work Plan for details of the geophysical methodologies and equipment to be used specifically for the issues listed in Section 3 of the approved Phase I Work Plan:

<u>Ground Penetrating Radar (GPR) Survey</u>

Geophysical Survey Systems Model SIR-3000 GPR

Antenna frequencies of 400, 500, 900, and 1600 MHz with data transferred to a PC

GSSI RADAN processing software to develop a 3-D model by combining all survey profiles

<u>Multi-Channel Analysis of Surface Waves (MASW) Survey</u>

A 20-pound hammer to strike a metal plate thereby generating seismic waves

Mark Products Model L-4 geophones to sense the seismic waves

Geometrics R-48 digital seismograph to record the signals

SEISIMAGER software to model each MASW sounding

Seismic Refraction Survey

A 20-pound hammer to strike a metal plate thereby generating seismic waves

24 Mark Products Model L-28 geophones to sense the seismic waves

Geometrics R-48 digital seismograph to record the signals

SEISIMAGER/R software to model the refraction data

Impact Echo Instrument Readings

Concrete Thickness Gauge, Model CTG-2

PC with Olson's WinCTG2 software for data acquisition and analysis

Electric Resistivity (ER)

Metal stake electrodes

Pentax PTS-III-10 total station to measure electrode elevations

AGI Super Sting R56 resistivity system

EARTHIMAGER-2D software to model the resistivity data

Verify Concrete Slab Thickness

Impact hammer drill with 1-inch bit. Grout holes upon completion

Inspection of Spillway Drains

Portable video camera or other portable equipment capable of traversing inside a 4-inch diameter drain pipe

Additional Equipment

Hammer, chain, plumb bob, 4-foot level, camera, ruler, 100-foot measuring tape, surveying equipment, flash light, 12-foot long No. 6 reinforcing steel rod for probing, and other small tools as necessary

F.5 Project Site Access for Paradise Dam Spillway

The general access to the upstream area and downstream area are shown on Figure P12 of the Phase I Work Plan. This access map may be updated based on our field evaluation in Task P-2.

GENTERRA will install anchor points at key locations (see Figure P13 through P16 in the Phase I Work Plan) for use during our field evaluation described in the approved Work Plan as well as for use by the District and DSOD personnel during future field evaluations. In order to install these anchors, safe access to the spillway chute should be identified. GENTERRA has identified proposed access ladder locations to safely access the spillway chute (see P15 through P17 in the Phase I Work Plan). Prior to site access, all personnel will go through our Site-Specific Health and Safety Plan (SSHSP) that is discussed below.

F.6 Site-Specific Health and Safety Plan for Paradise Dam Spillway

All personnel who will be on-site to execute the work that is described in the approved Work Plan will read and understand the Site-Specific Health and Safety Plan (SSHSP) before the start of the field work. In addition, daily safety meetings will be held at the project site, and personnel will be provided to assist in real-time review of the safety practices implemented throughout the field work. Proposed OSHA-Compliant Equipment that will be used during access to the spillway chute is shown on Figure P18 of the Phase I Work Plan. Similar anchor bolts were installed and load tested by GENTERRA per OSHA requirements for use in accessing steep abutments for maintenance work.

A Site-Specific Health and Safety Plan (SSHSP) has been prepared by GENTERRA to perform geophysical and exploratory drilling operations prior to mobilizing for the work. Specifics of the SSHSP implementation will be coordinated between PID and GENTERRA, and the geophysical subcontractor. A final version of the SSHSP is attached to the Phase I Work Plan as Attachment D.

F.7 Items to be provided by PID for Paradise Dam Spillway

F.7.1 Topographic Map for Paradise Dam Spillway

Due to time limitations to complete the work described in the Work Plan, GENTERRA proposes to use existing topographic mapping of the dam, spillway, and nearby surrounding areas for use in the geologic reconnaissance and eventual plotting of data for inclusion in the Phase I report.

PID may want to consider performing an updated topographic survey for use in future work to have more accurate data of the existing topography.

F.7.2 Access Ladders for Paradise Dam Spillway

As part of our field work, GENTERRA will install anchor points at key locations for use during our field evaluation described in the approved Work Plan as well as for use by PID and DSOD personnel during future field evaluations. During our field evaluation in Task P-2, we will identify the locations where access ladders can be stored and used as needed during the field work discussed in this project as well as for use by PID and DSOD personnel during future field evaluations. We will work with PID to identify the correct ladder type and anchor points for the ladders so that ladder will be stable during use. We have assumed that PID will purchase the ladders.

F.8 Environmental Disturbances and Mitigation Measures for Paradise Dam Spillway

Figures P5, P6, P8, P10, and P11 in the Phase I Work Plan provide views of the anticipated area to be utilized during the field work as described in the approved Work Plan. The actual work to be performed will be on the spillway structure, behind the spillway walls, downstream of spillway chute and slopes around the spillway structure. The following table lists potential disturbances during the field program, environmental impacts, and the planned mitigation measures where applicable to avoid any safety issues.

TABLE 5-1	
Potential Disturbance	**Remarks / Mitigation Measures**
General Access to the spillway area	Minimize disturbance by using existing path(s). Most work will be performed while walking on the ground and concrete surfaces and with fall protection and rope access, where needed. No excavation will be performed during the proposed work and we will not disturb existing environmental features during our field work

F.9 Project Schedule for Paradise Dam Spillway

The duration of the Phase I work as described in Tasks P-1 through P-8 in the previous sections is anticipated to have a total duration of approximately 4 months. The duration of the field work is expected to be a maximum of two to three weeks. During the field work, a seven-day work week will be utilized during the field evaluation, and the normal working hours are assumed to be from 7:00 A.M. until 5:30 P.M. Extended hours may be warranted on a special case scenario depending on the status of the individual tasks being performed. Representatives of GENTERRA and our Geophysics Subcontractor will be present during the field program to provide oversight of the field work. At least one representative from GENTERRA will be on-site at any given time during proposed field work. Not all personnel will be represented at all times.

SECTION G. PHASE II SPILLWAY ASSESSMENT (IF REQUIRED)

G.1 General for Both Spillways

If a Phase II Site Investigation is required based on the results of the Phase I Site Investigation, and as discussed with PID and DSOD, the Spillway Condition Assessment for either or both spillways would then include a concrete condition assessment and foundation evaluation consisting of a Non-Destructive Evaluation (NDE) investigation, as well as concrete and bedrock coring to obtain samples for laboratory testing to determine the physical properties of the existing concrete and for visual evaluation of the nature of the rock cores. We would review available project documentation to identify if any concrete cores or rock cores had previously been extracted from the spillway slabs and tested to determine the concrete or rock physical properties. Design of the repair alternatives requires data on the physical properties of the concrete to confirm that the repair methods and materials are compatible with the existing concrete. Evaluation of the nature of the bedrock cores will help to determine the bond length of anchor bars that is needed to tie-in the new concrete to the foundation and to provide sufficient sliding and uplift resistance.

If a Phase II Site Investigation is required, then a draft Phase II Work Plan will need to be prepared, and will include the locations and numbers of field coring, sampling, borings, and instrumentation needed for the condition assessment. Methodologies will be presented and explained for selecting parameters for the analysis.

The Phase II Work Plan will be developed for review and approval by PID and DSOD before any field work commences.

The Phase II Work Plan will also include a general description of any needed Phase II Site Investigations, if they are determined as being required based on the results of the Phase I Condition Assessment, and will include the plan to prepare a condition assessment report with results of site investigations and testing, descriptions of any required remedial measures, a matrix comparison of conceptual alternatives and ballpark costs for repairing any areas of existing distress. The intent of the Phase II site investigation and condition assessment report would be to select a preferred alternative, or combination of alternatives, with which to proceed into design, preparation of plans and specifications, and cost estimates. It is recognized that applications will need to be filed with DSOD for any alterations or repairs.

G.2 Phase II Field Investigation

A Phase II Site Investigation and Laboratory Testing Program may involve the following components:

- Extraction of concrete cores from the spillway slabs for laboratory examination and testing.
- Extraction of rock cores from the foundation materials for visual examination of the condition of the bedrock foundation.

Erodibility of the rock is a major concern downstream from the cutoff, beneath the spillway slab, and at the foundation elevations of the bridge piers and pipeline support piers. We will need to consider methods to quantify the erosion potential that goes beyond the visual mapping.

Drilling borings behind the right spillway wall to obtain soil samples of the backfill and dam embankment materials behind the right spillway wall.

G.3 Potential Phase II Non-Destructive Evaluation

If determined necessary, the Phase II NDE testing would be conducted on selected portions of the walls of the spillway, and on a grid basis throughout the entire exposed area of the spillway slabs. The NDE investigations will consist of Impact Echo (IE) and Spectral Analysis of Surface Waves (SASW) testing. The IE method will be used for evaluation of integrity and determination of depth and thickness of the concrete. The SASW method will be used to estimate surface-opening crack depths, estimate freeze-thaw damage depths, measure relative concrete quality and map areas of delamination or other cracking/degradation. Proper cleaning of the spillway channel prior to the proposed NDE is important to get reliable data and to provide a non-slippery working surface on which to conduct the field work.

The IE testing would be performed for the spillway slab at predetermined spacing intervals horizontally and vertically. SASW testing will be performed on a wider grid, and additional SASW tests would be performed across visible cracks or other locations of interest.

It is not good practice to rely only on Non-Destructive Evaluation testing for a concrete condition assessment. A minimal amount of strength testing of core samples is necessary to make a sound evaluation as indicated in *ACI 228.2R-13 Nondestructive Methods for Evaluation of Concrete in Structures,* and *ACI 207.3R-94 Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions, Section 3.9.2*. Consequently, a concrete coring program is needed to obtain samples for testing.

G.4 Potential Phase II Laboratory Testing Program

Visual examinations of all concrete core samples.

Visual examinations of all bedrock core samples.

Petrographic examination of concrete core samples to evaluate concrete composition, condition and quality, the presence and extent of concrete deterioration, and possible alkali-aggregate reaction. Examinations will be completed in accordance with ASTM C 856 and ASTM 1723.

Splitting tensile test of concrete core samples in accordance with ASTM C496.

Concrete compressive strength testing of concrete core samples to determine the concrete strength and to assist in assessing the concrete quality. Tests will be completed in accordance with ASTM C 42.

Modulus of elasticity testing of concrete core samples. Testing will be completed in accordance with ASTM C 569. Modulus of elasticity testing will be completed on the same concrete core samples used for compressive strength testing.

Performance of laboratory testing on soil samples for classification and to obtain strength parameters.

A Phase II Site Investigation and Spillway Condition Assessment Report will be prepared with details of the site investigation and laboratory testing program and with recommendations to provide input for the design, and in the preparation of plans and specifications for the selected alternative. The conceptual alternatives provided in the reports would include options for repairs/modifications to the spillway to improve the overall safety of the dams as related to operation of the spillway. These alternatives would be examined during an alternatives analysis, and consideration will be given for ease of approval by DSOD.

SECTION H. REVIEW AND COORDINATION

Throughout the performance of the work described in this proposal, communications between GENTERRA, PID, and DSOD will be maintained as necessary to keep all parties informed on progress and to confirm the acceptance of the proposed approach and methodology. PID is responsible for coordination with all agencies. Communication with any contractors for field safety preparation and drilling procedures will be coordinated through GENTERRA and PID.

SECTION I. PROPOSED PROJECT SCHEDULE

We anticipate that it will take about 4 months to complete the tasks discussed in this proposal from the Notice to Proceed and can be completed by end of February 2018. A detailed and meaningful Project Schedule will be prepared once we receive the Notice to Proceed. The proposed project schedule was prepared with the assumption that PID will be issuing a Notice to Proceed soon enough to enable starting the document review process in Task 1 by November 1, 2017. The specific schedules for each spillway are discussed in the Section E.9 for Magalia Dam and Section F9 for Paradise Dam, respectively. The schedules will be modified as necessary and as mutually-agreed based on the actual date of the Notice-to-Proceed.

Please note that we have the capability to possibly accelerate the proposed project schedule, if needed. We can commence the work on the next working day after receiving the Notice-to-Proceed.

SECTION J. ESTIMATED PROJECT FEE AND HOURS

GENTERRA will perform the proposed services on a time and materials basis in accordance with the attached Professional Fee Schedule. This is a reduced fee schedule with 2015 rates and with the same rates as our current contract with PID. ***To further reduce costs, we have identified several project team members to be billed at classifications lower than their normal fee schedule classifications.*** These are identified on the attached cost spreadsheet. We will only perform the services that are necessary and are authorized by you.

The estimated maximum cost to implement the Phase I Work Plans and complete all the tasks for both spillways is $XXX,XXX. A spreadsheet showing a breakdown of the estimated hours and costs is attached.

The costs in the attached spreadsheet include labor charges and expenses for travel from Sacramento, and reproduction. We will not exceed the authorized fee without your authorization.

Current Fee Schedule Page 1 of 2

Current Fee Schedule Page 2 of 2

Estimated Hours and Costs by Task

Cost Estimate - PID Dams - Spillway Condition Assessments - PHASE I IMPLEMENTATION
Paradise Irrigation District
Proposal No. P2335
10/10/17 JJK Draft - PHASE I IMPLEMENTATION

PID DAMS - SPILLWAY CONDITION ASSESSMENTS WORK PLANS
PER REDUCED 2015 FEE SCHEDULE FOR ***(See Note 1)***

MAGALIA DAM PHASE I IMPLEMENTATION

TASK	Classification (*See Note 1*) ---> / Role ---> / Initials ---> / Hourly Rate (*See Note 1*) ----->	Sr. Princ. Eng/ Proj. Mgr JJK $265	Principal Engineer SB $245	Sr. Associate Engineer CH/DAH $220	Associate Geologist MW $210	Project Engineer SL $180	Sr. Staff Geologist KMM $160	Senior Field Technician JWK $120	Office Assistant TMC/MAG $60	Total Hours	Subtotal Labor Cost	In-House Expenses (See Notes): Equipment Use (See Note 2)	Repro, Mileage & Subsistence (See Notes 3 & 4)	Subtotal In-house Expenses	Geophysics Subcontractor (15% Markup) (See Note 5)	TOTAL COST
M-1	Document Acquisition and Review	12	10	10	8	8	8	4	2	62	$ 12,830	$ -	$ 836	$ 836	$ -	**$ 13,666**
M-2	Field Evaluation and Non-Destructive Evaluation	5	10	10	0	10	0	10	4	49	$ 9,215	$ 800	$ 1,144	$ 1,944	$ -	**$ 11,159**
M-3	Geologic Reconnaissance and Surficial Mapping	0	0	0	10	10	4	10	0	34	$ 5,740	$ 800	$ 550	$ 1,350	$ -	**$ 7,090**
M-4	Geophysical Survey	2	2	0	2	0	0	60	2	68	$ 8,760	$ -	$ 1,016	$ 1,016	$ 31,680	**$ 41,456**
M-5	Engineering Evaluation	4	12	12	4	24	4	2	0	62	$ 12,680	$ -	$ 126	$ 126	$ -	**$ 12,806**
M-6	Phase I Spillway Condition Assessment Report	16	32	12	12	32	30	16	6	156	$ 30,080	$ -	$ 360	$ 360	$ -	**$ 30,440**
M-7	Project Management, Review & Discussion with PID & DSOD	40	8	0	0	0	0	0	12	60	$ 13,280	$ -	$ 412	$ 412	$ -	**$ 13,692**
M-8	Phase II Work Plan (If Needed)	8	12	6	4	4	8	6	2	50	$ 10,060	$ -	$ 105	$ 105	$ -	**$ 10,165**
TOTALS		**87**	**86**	**50**	**40**	**88**	**54**	**108**	**28**	**385**	**$ 102,645**	**$ 1,600**	**$ 4,547**	**$ 6,147**	**$ 31,680**	**$ 140,473**

PARADISE DAM PHASE I IMPLEMENTATION

TASK	Classification (*See Note 1*) ---> / Role ---> / Initials ---> / Hourly Rate (*See Note 1*) ----->	Sr. Princ. Eng/ Proj. Mgr JJK $265	Principal Engineer SB $245	Sr. Associate Engineer CH/DAH $220	Associate Geologist MW $210	Project Engineer SL $180	Sr. Staff Geologist KMM $160	Senior Field Technician JWK $120	Office Assistant TMC/MAG $60	Total Hours	SubTotal Labor Cost	In-House Expenses (See Notes): Equipment Use (See Note 2)	Repro, Mileage & Subsistence (See Notes 3 & 4)	Subtotal In-house Expenses	Geophysics Subcontractor (15% Markup) (See Note 5)	TOTAL COST
P-1	Document Acquisition and Review	12	10	10	8	8	8	4	2	62	$ 12,830	$ -	$ 836	$ 836	$ -	**$ 13,666**
P-2	Field Evaluation and Non-Destructive Evaluation	5	10	10	0	10	0	10	4	49	$ 9,215	$ 800	$ 1,948	$ 2,748	$ -	**$ 11,963**
P-3	Geologic Reconnaissance and Surficial Mapping	0	0	0	10	10	4	10	0	34	$ 5,740	$ 800	$ 1,352	$ 2,152	$ -	**$ 7,892**
P-4	Geophysical Survey	2	2	0	2	10	0	90	0	106	$ 14,040	$ 800	$ 2,576	$ 3,376	$ 40,290	**$ 57,706**
P-5	Engineering Evaluation	4	12	12	0	24	4	16	6	78	$ 13,880	$ -	$ 126	$ 126	$ -	**$ 14,006**
P-6	Phase I Spillway Condition Assessment Report	16	32	12	8	32	30	16	8	154	$ 29,360	$ -	$ 360	$ 360	$ -	**$ 29,720**
P-7	Project Management, Review & Discussion with PID & DSOD	40	8	0	0	0	0	0	12	60	$ 13,280	$ -	$ 314	$ 314	$ -	**$ 13,594**
P-8	Phase II Work Plan (If Needed)	8	12	6	8	4	8	6	4	56	$ 11,020	$ -	$ 105	$ 105	$ -	**$ 11,125**
TOTALS		**87**	**86**	**50**	**36**	**98**	**54**	**152**	**36**	**427**	**$ 109,365**	**$ 2,400**	**$ 7,616.03**	**$ 10,016.03**	**$ 40,290.25**	**$ 159,671**

Personnel Initials and Names:

- JJK - Joseph J. Kulikowski, P.E., G.E.
- SB - Soma Balachandran, Ph.D., P.E., G.E.
- CH - Chuck Hutton, P.E.(Rate Reduced from Principal)
- DAH - Douglas A. Harriman, P.E.(Rate Reduced from Principal)
- MW - Mike Wolff, P.G., C.E.G. (Rate Reduced from Principal)
- SL - Shuyu Liu, P.E. (Rate Reduced from Senior Project Engineer)
- KMM - Kristina M. Mohos
- JWK - J. William Kulikowski (Rate Reduced from Supervisory Technician)
- TMC/MAG - Tanya M. Cason/Mary A. Gunnison

NOTES

1. A reduced fee schedule is applied, which is the reduced 2015 Fee Schedule submitted in 2015. Also, Classifications and Rates for some personnel were reduced from Fee Schedule to further reduce costs.
2. GENTERRA's equipment charges are shown in detail on Sheets 2 and 3.
3. Reproduction is for limited documents in Irvine plus an estimated $600 for outside costs to obtain and scan selected documents from DSOD. Only actual costs will be charged to PID. See Sheets 2 and 3 for breakdown.
4. Travel for GENTERRA personnel will be from our Sacramento office to DSOD for files review and to Paradise, CA for the field evaluations. Subsistence is for overnight stays in Paradise. See Sheets 2 and 3 for breakdown.
5. The costs for the Geophysics Subcontractor are detailed on Sheets 4 and 5. GENTERRA's Markup is per the fee schedule but can be discussed.

GENTERRA's Senior Field Technican and On-Site Health and Safety officer will be present during all field work by GENTERRA personnel as well as the work by the geophysical survey subcontractor.

Cost Estimate - PID Dams - Spillway Condition Assessments - PHASE I IMPLEMENTATION
Paradise Irrigation District
Proposal No. P2335
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PID DAMS - SPILLWAY CONDITION ASSESSMENTS WORK PLANS
COST ESTIMATE FOR EXPENSES

	MAGALIA DAM PHASE I IMPLEMENTATION													
		GENTERRA Expenses (Mileage, Subsistence, Repro., Field Equipment & Supplies)								Subcontracting Expenses				
TASK	DESCRIPTION	Units	Rate	Qty	Mileage Cost (See Note A)	Subsistence (See Note B)	Repro. Misc. (See Note C)	Field Equip. / Supplies (See Note D)	Subtotal	Subcontractor's Name	Cost	Markup (15%)	Subtotal	TOTAL COST FOR EXPENSES
M-1	Document Acquisition and Review	mi	$ 0.535	20	$ 11	$ -	$ 825	$ -	$ 836					$ 836
M-2	Field Evaluation and Non-Destructive Evaluation	mi	$ 0.535	372	$ 199	$ 900	$ 45	$ 800	$ 1,944					$ 1,944
M-3	Geologic Reconnaissance and Surficial Mapping	mi	$ 0.535	186	$ 100	$ 450	$ -	$ 800	$ 1,350					$ 1,350
M-4	Geophysical Survey	mi	$ 0.535	216	$ 116	$ 900	$ -	$ -	$ 1,016	Terra Physics	$ 27,548	$ 4,132	$ 31,680	$ 32,696
M-5	Engineering Evaluation	mi	$ 0.535	0	$ -	$ -	$ 126	$ -	$ 126					$ 126
M-6	Phase I Spillway Condition Assessment Report	mi	$ 0.535	0	$ -	$ -	$ 360	$ -	$ 360					$ 360
M-7	Project Management, Review & Discussion with PID & DSOD	mi	$ 0.535	186	$ 100	$ 300	$ 12	$ -	$ 412					$ 412
M-8	Phase II Work Plan (If Needed)	mi	$ 0.535	0	$ -	$ -	$ 105	$ -	$ 105					$ 105
TOTAL FOR EXPENSES AND SUBCONTRACTING SERVICES					$ 524	$ 2,550	$ 1,473	$ 1,600	$ 6,147				$ 31,680	$ 37,828

NOTES

A. Travel for GENTERRA personnel will be from our Sacramento office to DSOD for files review and to Paradise, CA for the field evaluations. Only actual costs will be charged to PID.
In Task M-1: Roundtrip to DSOD from Sacramento office is estimated to be 20 miles
In Task M-2: Roundtrip to Magalia Dam from Sacramento office is estimated to be 186 miles. Six personnel will travel in two separate vehicles. (2*186=372 miles)
In Task M-3: Roundtrip to Magalia Dam from Sacramento office is estimated to be 186 miles. Three personnel will travel in one vehicle.
In Task M-4: Roundtrip to Magalia Dam from Sacramento office is estimated to be 186 miles. About 30 miles was added for local travel during six days of geophysical work
In Task M-7: Roundtrip to Magalia Dam from Sacramento office is estimated to be 186 miles to attend one in-person meeting, if needed.

B. Subsistence is for overnight stay in Paradise and will be charged at $150 per night per person. Only actual costs will be charged to PID.
In Task M-2: Six personnel will stay one night at Paradise (6*$150=$900)
In Task M-3: Three personnel will stay one night at Paradise (3*$150=$450)
In Task M-4:One personnel will stay six nights at Paradise (6*$150=$900)
In Task M-7: Two personnel will stay one night at Paradise (2*$150=$300), if needed.

C. Reproduction is for limited documents in Irvine plus an estimated $600 for outside costs to obtain and scan selected documents from DSOD. Only actual costs will be charged to PID.
In-house photocopy/reproduction will be billed at $0.15 per page for black-and-whote copies and $1.50 per page for color copies.
In Task M-1: In-house copy: 500*$0.15+100*$1.50 + Outside Copy of DSOD Files: $600 = $825
In Task M-2: In-house copy: 50*$0.15+250*$1.50 = $45
In Task M-5: In-house copy: 240*$0.15+60*$1.50 = $126
In Task M-6: In-house copy: 400*$0.15+200*$1.50 = $360
In Task M-7: In-house copy: 80*$0.15 = $12
In Task M-8: In-house copy: 200*$0.15+50*$1.50 = $105

D. Daily rate for Equipment and Supplies is calculated as follows:
Impact Echo Equipment = $250 + Chain and Hammer = $50 + Harness & Hardware for Access = $200 + Vehicle Usage = $120 + Misc. Field Supplies = $170 = $800 per day
Non-destructive field testing will be conducted in Task M-2 and will be continued while Task M-3 is in progress as well.

Cost Estimate - PID Dams - Spillway Condition Assessments - PHASE I IMPLEMENTATION
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PID DAMS - SPILLWAY CONDITION ASSESSMENTS WORK PLANS
COST ESTIMATE FOR EXPENSES

TASK	DESCRIPTION	Units	Rate	Qty	Mileage Cost	Per Diem	Repro. Misc.	Field Equip./ Supplies	Subtotal	Subcontractor's Name	Cost	Markup (15%)	Subtotal	TOTAL COST FOR EXPENSES
	PARADISE DAM PHASE I IMPLEMENTATION													
		GENTERRA Expenses (Mileage, Subsistence, Repro., Field Equipment & Supplies)								Subcontracting Expenses				
P-1	Document Acquisition and Review	mi	$ 0.535	20	$ 11	$ -	$ 825	$ -	**$ 835.70**					**$ 836**
P-2	Field Evaluation and Non-Destructive Evaluation	mi	$ 0.535	380	$ 203	$ 900	$ 45	$ 800	**$1,948.30**					**$ 1,948**
P-3	Geologic Reconnaissance and Surficial Mapping	mi	$ 0.535	190	$ 102	$ 450	$ -	$ 800	**$1,351.65**					**$ 1,352**
P-4	Geophysical Survey	mi	$ 0.535	235	$ 126	$ 1,650	$ -	$ 800	**$2,575.73**	Terra Physics	$ 35,035	$ 5,255	$ 40,290	**$ 42,866**
P-5	Engineering Evaluation	mi	$ 0.535	0	$ -	$ -	$ 126	$ -	**$ 126.00**					**$ 126**
P-6	Phase I Spillway Condition Assessment Report	mi	$ 0.535	0	$ -	$ -	$ 360	$ -	**$ 360.00**					**$ 360**
P-7	Project Management, Review & Discussion with PID & DSOD	mi	$ 0.535	190	$ 102	$ 200	$ 12	$ -	**$ 313.65**					**$ 314**
P-8	Phase II Work Plan (If Needed)	mi	$ 0.535	0	$ -	$ -	$ 105	$ -	**$ 105.00**					**$ 105**
TOTAL FOR EXPENSES AND SUBCONTRACTING SERVICES					**$ 543**	**$ 3,200**	**$ 1,473**	**$ 2,400**	**$ 7,616**				**$ 40,290**	**$ 47,906**

NOTES

A. Travel for GENTERRA personnel will be from our Sacramento office to DSOD for files review and to Paradise, CA for the field evaluations. Only actual costs will be charged to PID.
In Task P-1: Roundtrip to DSOD from Sacramento office is estimated to be 20 miles
In Task P-2: Roundtrip to Paradise Dam from Sacramento office is estimated to be 190 miles. Six personnel will travel in two separate vehicles. (2*190=380miles)
In Task P-3: Roundtrip to Paradise Dam from Sacramento office is estimated to be 190 miles. Three personnel will travel in one vehicle.
In Task P-4: Roundtrip to Paradise Dam from Sacramento office is estimated to be 190 miles. About 45 miles was added for local travel during nine days of geophysical work
In Task P-7: Roundtrip to Paradise Dam from Sacramento office is estimated to be 190 miles to attend one in-person meeting, if needed.

B. Subsistence is for overnight stay in Paradise and will be charged at $150 per night per person. Only actual costs will be charged to PID.
In Task P-2: Six personnel will stay one night at Paradise (6*$150=$900)
In Task P-3: Three personnel will stay one night at Paradise (3*$150=$450)
In Task P-4: Two personnel will stay one night at Paradise (2*$150=$450) and one personnel will stay nine nights at Paradise (9*$150) = $1650
In Task P-7: Two personnel will stay one night at Paradise (2*$150=$300), if needed.

C. Reproduction is for limited documents in Irvine plus an estimated $600 for outside costs to obtain and scan selected documents from DSOD. Only actual costs will be charged to PID.
In-house photocopy/reproduction will be billed at $0.15 per page for black-and-whote copies and $1.50 per page for color copies.
In Task P-1: In-house copy: 500*$0.15+100*$1.50 + Outside Copy of DSOD Files: $600 = $825
In Task P-2: In-house copy: 50*$0.15+250*$1.50 = $45
In Task P-5: In-house copy: 240*$0.15+60*$1.50 = $126
In Task P-6: In-house copy: 400*$0.15+200*$1.50 = $360
In Task P-7: In-house copy: 80*$0.15 = $12
In Task P-8: In-house copy: 200*$0.15+50*$1.50 = $105

D. Daily rate for Equipment and Supplies is calculated as follows:
Impact Echo Equipment = $250 + Chain and Hammer = $50 + Harness & Hardware for Access = $200 + Vehicle Usage = $120 + Misc. Field Supplies = $170 = $800 per day
Non-destructive field testing will be conducted in Task P-2 and will be continued while Tasks P-3 and P-4 are in progress as well.

PID DAMS - SPILLWAY CONDITION ASSESSMENTS WORK PLANS
COST ESTIMATE FOR GEOPHYSICAL SURVEY BY TERRA PHYSICS
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	MAGALIA DAM PHASE I IMPLEMENTATION	
TASK	**DESCRIPTION**	**Cost**
M-4.1	Project Management/Mob & Demob	$ 3,570
M-4.2	Field Work for Six Consecutive Days (6@$2373 per day)	$ 14,328
M-4.3	Expense only for one stanby day in case of weather delay or site access delay	$ 500
M-4.4	Data Processing in the office for 11 days (11@$850 per day)	$ 7,650
M-4.5	Report	$ 1,500
TOTAL EXPENSES FOR GEOPHYSICAL SURVEY (WITHOUT MARKUP)		**$ 27,548**

PID DAMS - SPILLWAY CONDITION ASSESSMENTS WORK PLANS
COST ESTIMATE FOR GEOPHYSICAL SURVEY BY TERRA PHYSICS
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	PARADISE DAM PHASE I IMPLEMENTATION	
TASK	**DESCRIPTION**	**Cost**
P-4.1	Project Management/Mob & Demob	$ 5,315
P-4.2.1	Field Work for Six Consecutive Days (7@$2100 per day)	$ 14,700
P-4.2.2	Field Work for Two Consecutive Days (2@$2760 per day)	$ 5,520
P-4.3	Expense only for one stanby day in case of weather delay or site access delay	$ 500
P-4.4	Data Processing in the office for 10 days (10@$750 per day)	$ 7,500
P-4.5	Report	$ 1,500
TOTAL EXPENSES FOR GEOPHYSICAL SURVEY (WITHOUT MARKUP)		**$ 35,035**