SSFL CDO Expert Panel[1]

Robert Gearheart, Ph.D., P.E.
Richard Horner, Ph.D., P.E.
Jonathan Jones, P.E., D.WRE
Michael Josselyn, Ph.D.
Robert Pitt, Ph.D., P.E., BCEE, D.WRE
Michael K. Stenstrom, Ph.D., P.E., BCEE

OVERVIEW OF THE ALTERNATIVES EVALUATION PROCESS FOR ENTS FACILITIES IN SSFL DRAINAGE SUBBASINS 008 AND 009

EXECUTIVE SUMMARY

This white paper was prepared by the Expert Panel (Panel) that was formed to provide recommendations for Engineered Natural Treatment Systems (ENTSs) to treat stormwater runoff in drainage subbasins 008 and 009 at the Santa Susana Field Laboratory (SSFL).

The purpose of the paper is to summarize the methodology used by the Panel to review background information, evaluate alternatives, and provide recommendations for the conceptual designs of ENTS facilities. The final conceptual ENTS designs, as shown in the June conceptual design package, are the Expert Panel's preferred and recommended natural treatment strategy for improving stormwater quality at Outfalls 008 and 009. The Panel's recommendations are consistent with directives from the Los Angeles Regional Water Quality Control Board (RWQCB) stated in Cease and Desist Order #R4-2007-0056 adopted in November 2007. As the designs progress from a conceptual stage to final design, the Panel will continue to investigate optimizing their performance.

A broad range of background information related to SSFL was evaluated by the Panel. Information reviewed included pertinent regulatory documents, physical characteristics of the site, and unique constraints with implementing the ENTS facilities. In addition, public input was provided to the Panel during meetings held in January, March, April and June, 2008. Panel members also routinely met with and received input from the RWQCB and were frequently briefed by Geosyntec, MWH, Boeing, and other interested parties.

Fifteen guiding principles were adopted by the Panel for use in planning, evaluating, and selecting ENTS facilities for the 008 and 009 basins. Foremost of these principles was

[1] The Expert Panel members are acting as private consultants in order to assist the Regional Board and The Boeing Company develop and implement methods to meet the requirements of Cease and Desist Order R4-2007-0056, dated November 1, 2007. Their opinions and directives are not the opinions and directives of their respective employers.

the objective to meet the National Pollutant Discharge Elimination System (NPDES) numeric permit limits to the maximum extent feasible. The methodology used by the Panel to develop and select conceptual designs for the ENTS facilities involved six major steps:

1) Identify the design storm used as an initial basis for ENTS designs
2) Identify suitable locations for the ENTS facilities
3) Evaluate hydrologic model results for ENTS facilities
4) Evaluate alternative configurations of ENTS facilities
5) Finalize the design storm and ENTS concepts, and
6) Refine ENTS designs

Using the guiding principles and design methodology, more than three dozen stormwater treatment projects have been proposed for the 008 and 009 subbasins. These projects range from asphalt removal projects, which will decrease runoff rates and volumes, to treatment trains with multiple treatment processes in series.

To illustrate the process used to formulate, evaluate and select alternatives, major considerations and design steps are discussed for the LOX ENTS, culvert modifications, biological treatment facilities, and the Ash Pile site. These examples demonstrate the multi-faceted nature of the design decisions and provide a basis for the alternatives that were ultimately selected.

It is the Panel's intent that the resulting overall recommended stormwater program for the 008 and 009 watersheds will result in a sustainable set of controls that exceed the standard practice for stormwater treatment systems nationally. The ENTS facilities are designed to meet the numerical effluent limits established by the RWQCB, to the extent feasible and within the practical limits of the ENTS technology. The proposed facilities are viewed as temporary projects that will be kept in place while ongoing environmental remediation activities at SSFL are occurring.

1.0 INTRODUCTION

This white paper was prepared by the Expert Panel (Panel) that was formed to provide recommendations for Engineered Natural Treatment Systems (ENTSs) to treat stormwater runoff in drainage subbasins 008 and 009 at the Santa Susana Field Laboratory (SSFL). Geosyntec Consultants assisted the Panel with the development of this document. The purpose of this paper is to summarize the methodology and approaches used by the Panel to review site background information, conceptualize and evaluate alternatives, and provide recommendations for the conceptual designs of ENTS facilities. Major topics addressed in this paper are as follows:

- Regulatory and other background information considered
- Guiding principles of the ENTS designs
- Conceptual site selection and design methodology
- ENTS alternatives evaluated
- Summary and conclusions

The final conceptual ENTS designs, as shown in the June conceptual design package, are the Expert Panel's preferred and recommended natural treatment strategy for improving stormwater quality at Outfalls 008 and 009. The Panel's recommendations are consistent with directives from the Los Angeles Regional Water Quality Control Board (RWQCB) stated in Cease and Desist Order #R4-2007-0056 adopted in November 2007. As the designs progress from a conceptual stage to final design, the Panel will continue to investigate optimizing their performance.

2.0 REGULATORY AND OTHER BACKGROUND INFORMATION CONSIDERED

A broad range of information was reviewed and considered in the formulation and evaluation of alternative conceptual designs of the ENTS facilities. Background information considered by the Panel is summarized below, including pertinent regulatory documents, key site characteristics and constraints, as well as other relevant supporting information.

2.1 Clean Water Act Regulatory Documents

2.1.1 Cease and Desist Order

Cease and Desist Order #R4-2007-0056, adopted on November 1, 2007 by the Los Angeles Regional Water Quality Control Board, established requirements for stormwater quality management in the 008 and 009 subbasins. The Cease and Desist Order requires a study of ENTS facilities, including such elements as their design and implementation with the ultimate objective of meeting permit limits at these outfalls. Item 43 in the Cease and Desist Order states:

During discussions with the Permittee on February 23, 2007, there was a request to treat the discharges from Outfalls 008 and 009 differently from the other storm water only outfalls. Outfalls 008 and 009 are located in jurisdictional drainages where engineered BMP installation may be impractical. Historical data confirms that treatment is required to meet the effluent limitations included in the NPDES permit. The Permittee has proposed a conceptual natural BMP design study as the mechanism to meet the final effluent limitations proposed for discharges from these locations. The natural BMPs will be strategically located to control erosion and sediment from specific source areas, and RCRA RFI Sites throughout the subwatershed. The natural BMPs will include erosion and sediment controls (such as surface roughening and use of soil binders) and structural treatment devices (such as treatment wetlands and bioretention areas). An independent team of experts will be convened to evaluate site conditions including contaminants in the vicinity, evaluate the natural BMPs, their documented effectiveness and their performance under site conditions, to select the appropriate BMPs, the design and implementation. The goal of the natural BMPs implemented is to meet the final effluent limitations included in Order R4-2007-0055.

Item 43 of the Cease and Desist Order mandates the formation of an Expert Panel to evaluate and select appropriate measures to treat stormwater discharges from Outfalls 008 and 009 "…to meet the final effluent limitations in Order R4-2007-0055."

2.1.2 NPDES Permit (Order R4-2007-0055)

The governing regulatory requirement for stormwater at the SSFL is to comply with numeric limits specified in the National Pollutant Discharge Elimination System (NPDES) permit No. R4-2007-0055 (Permit) and subsequent Amending Orders to the Permit, most recently revised on November 1, 2007. The Permit lists numeric limits for more than 20 different parameters (the number of permitted parameters varies by Outfall). When proposing alternatives to be evaluated, the Panel has focused on ENTSs that are most effective for treating the specific pollutants listed in the Permit (particularly for the low effluent limits prescribed for many parameters), while also being feasible and appropriate for implementing at the site.

2.2 Site Characteristics

During the course of defining and evaluating alternative ENTS's, a wide range of characteristics for subbasins 008 and 009 were accounted for by the Panel, as described below.

Precipitation Data—Precipitation data for the site were evaluated by the Panel to provide the basis for continuous hydrologic modeling and to determine an appropriate design storm for the ENTS facilities. Data from multiple rain gages in the general vicinity of SSFL were evaluated and correlated against rainfall data from an onsite rain gage to generate a suitable long-term hourly precipitation record (1948–2006) for use in modeling the site.

Hydrology—Extensive hydrologic modeling of the 008 and 009 subbasins was conducted by Geosyntec Consultants using the United State Environmental Protection Agency (USEPA) SWMM model. The modeling work was directed and reviewed by the Panel. Model results included long-term, continuous simulations as well as design storm analyses (selected 2.5 inches over 24 hours or an intensity of 0.6 inches per hour to meet the goal of providing treatment of 90 percent of the runoff, while considering habitat and other feasibility issues). These model simulations were used to evaluate the long-term average volume capture of the ENTS facilities. Panel members conducted independent hydrologic analyses (using alternative calculations and models) to verify the reasonableness of the SWMM results.

Groundwater Contamination—A key design guideline identified by the Panel was to limit the mobilization of groundwater contaminants by minimizing additional infiltration in areas where groundwater contamination is known to exist. The inability to enhance infiltration as a design feature at most proposed ENTS locations is of particular importance at locations such as the LOX and Ash Pile RCRA Facility Investigation (RFI) areas, as discussed below. The Panel was thoroughly briefed on groundwater contamination issues by staff from Boeing and Boeing's remediation consultants.

Soil Contamination—Mapping of soil contamination at SSFL was compiled by Boeing, its remediation consultants and Geosyntec and provided to the Panel to consider when evaluating potential ENTS locations. Planned remediation of contaminant source areas and surface soils was also considered in the ENTS planning process. Data evaluated included soil sample locations, results relative to soil screening levels, SSFL background soil concentration levels, and preliminary estimates of impacted soil volumes.

Surface Water Contamination—Surface water quality monitoring results were compiled by MWH and Geosyntec and provided to the Panel for review. Based on Total Suspended Solids (TSS) data correlations with other permit parameters from the different outfalls and/or with soil contaminant data, an assessment was made of the TSS concentrations in outfall 009 that would be necessary to meet NPDES effluent standards for specific contaminants. For example, with TCDD, an extremely low concentration of Total Suspended Solids (TSS) (less than 1 mg/l) would be necessary to assure that the NPDES permit limit for TCDD would not be exceeded (based on calculations using background soil levels assumed to be suspended in stormwater).

The report titled *Potential Background Constituent Levels in Storm Water at Boeing's Santa Susana Field Laboratory*, prepared by Flow Science, Inc. (dated May 1, 2007), as well as other sources of background data were also reviewed by the Panel.

Topography and Soils Characteristics—Topographic and soil hydrologic data for the site were incorporated in the hydrologic modeling as well as in the conceptual ENTS designs. Panel members participated in field trips to familiarize themselves with the site features, particularly in areas where ENTS facilities were being considered. Steep slopes and soil

characteristics in basins 008 and 009 have a direct bearing on the amount of soil erosion and contaminant transport as well as the feasibility of alternative ENTS concepts.

Vegetation—Vegetation is one of the primary features considered for the ENTS locations. To meet strict California Environmental Quality Act (CEQA) requirements, vegetation in higher value habitat areas is to be minimally disturbed, such as in riparian corridors and in areas with highly valued species, such as oak trees. Other factors to consider include the location of areas burned in the 2005 Topanga fire, and the use of native vegetation in the ENTS's. Biologists and arborists surveyed all preliminary proposed ENTS footprint areas to support the CEQA impacts analysis and to inform the conceptual design effort.

Existing Infrastructure and Land Uses—The existing infrastructure at the site, including roads and utilities, was considered by the Panel during the development of ENTS alternatives. Access to the ENTS facilities is necessary for system construction and maintenance. Minimizing impacts to existing utilities is a practical consideration. Compatibility with existing and future land uses is consistent with the Panel's initial list of guiding principles, first identified in the Panel's report titled "*Final Consensus Recommendation on a Site Specific Design Storm for the Santa Susana Field Laboratory,*" dated April 30, 2008.

2.3 Site Constraints

Multiple site constraints influenced the alternatives that were developed and evaluated by the Panel, and significantly affected the final locations and conceptual design of the ENTS facilities. (Figures 1A and 1B show the proposed ENTS facilities in the 008 and 009 subbasins as of late June, 2008.) Brief descriptions of major site constraints include:

Water Quality Effectiveness – NPDES Permit limits are very low and the Panel unanimously acknowledged that an exceptionally effective system of engineered natural treatment systems would be required to meet the limits, or to at least significantly improve the frequency with which they are met. A fundamental constraint identified was maximizing pollutant removal effectiveness through the siting, sizing, selection of treatment processes, and development of design details for the proposed ENTS facilities.

Hydraulics – During ENTS siting, preference was given to hydraulically-optimal sites. These are sites that are downgradient from targeted "source" areas, such as areas with historic industrial activities, known surface soil contamination, development, and/or large drainage areas. The intent is to increase the volume capture of downstream ENTS facilities without the use of pumping. Only gravity driven systems were considered to be consistent with the overall *natural* treatment system requirement in the Cease and Desist Order and long-term future uses for the site (i.e., open space).

Erosion and Debris Flow—Steep topography, limited vegetation, erodible soils and the residual effects of wildfires in the 008 and 009 subbasins have resulted in a range of site-specific constraints, including, but not limited to, channel erosion, soil erosion (via overland flow), the potential for significant sediment and debris flows during large storms, and the need to construct embankments to store runoff and settle out solids. The

"hungry water" phenomenon, which can lead to channel erosion downstream from large ENTS's, was accounted for by the Panel when considering alternatives.

Access—The steep topography at the SSFL requires that special consideration be given for providing access for construction and long-term maintenance of the ENTS facilities. Maintenance access for the ENTS facilities is essential to ensure their successful long-term treatment and operational performance.

Riparian Corridor and Natural Resources Protection—The need to protect riparian corridors and vegetation has been identified as a critical consideration, with special attention directed toward specific stands of oak trees at locations such as the LOX and Ash Pile sites. Areas where vegetation was already impacted through past activity or development were given particular consideration.

Prohibition to Modify Existing Ecology and Habitat—A premise of the ENTS designs is that the treatment facilities will not significantly impact the existing ecology or habitat. For example, constructed ENTS must be ephemeral features, not perennial, given the current site hydrologic and habitat characteristics. Native vegetation will be used in the ENTS.

Seismic Potential—Seismic activity in the region has a direct bearing on the alternatives considered by the Panel, given the significant urban development immediately downslope from the 008/009 Outfalls. Comments received from the public clearly indicate that large dams are not a preferred option for the ENTS facilities, given the implications to public safety of their failure.

Environmental Permitting and Ongoing RCRA Cleanup Requirements—Local, state and federal environmental permitting requirements impose important constraints regarding the locations and nature of the ENTS facilities. Requirements include ongoing cleanup required by the Resource Conservation and Recovery Act (RCRA), numeric limits in the NPDES permit, and specific requirements from the California Department of Fish and Game (CDFG), Army Corps of Engineers (ACOE), and the RWQCB regarding proposed activities in the drainage.

Fire History and Potential—The chaparral vegetation at the SSFL is prone to periodic wildfires, with subsequent increased runoff, erosion, and potential debris flows. This was made evident by the Topanga fire that burned the site in September 2005. ENTS facilities at the SSFL have been designed with consideration of the possible occurrence of fires, with features such as conservatively sized spillways for embankments and sedimentation basins upstream from bioretention facilities to limit frequent clogging.

Stormwater Run-on from Adjacent Properties—Substantial run-on to subbasin 009 occurs from the Sage Ranch property. Any treatment facilities proposed for this offsite area must be approved by the Sage Ranch owner if the treatment facility encroaches on their property.

NASA Ownership of Property—Much of the 009 subbasin is owned by the National Aeronautics and Space Administration (NASA). Portions of the 009 subbasin are strategically located in more downstream areas that are ideal for implementation of ENTSs. Consequently, NASA's approval is required for the following ENTSs that are proposed on their property:

- Asphalt Removal Site 1
- Treatment Trains 1, 2, and 3 (LOX)
- Grade Control Sites 1 and 2
- Biological Treatment Sites 1 (Ash Pile bioretention basin), 2 (Ash Pile bioswale), 3 and 4
- Culvert Maintenance Site 1

2.4 Other Information Considered When Formulating and Evaluating Alternatives

Numerous information sources were utilized by the Panel to conceptualize and evaluate alternative ENTS's including the following:

Public Input—A critical source of information considered by the Panel while evaluating ENTS alternatives was the input received from the public. To date in 2008, Panel members have met with the public on January 22, March 17, April 17, and June 5, and participated in a field trip on April 16, 2008. Public comments were considered in addition to input given by Geosyntec, MWH, Boeing, and others. In the Panel's experience, although atypical, it is beneficial for many diverse parties to provide input on the formulation and design of stormwater treatment facilities. This level of interest, from property owners to downstream neighbors, provides a broad range of perspectives on the requirements of the ENTS facilities and on the nature of alternatives to be considered.

Certain common themes were raised by many of the commenting parties. For example, there is great reluctance to consider large dams in the two subbasins. This opinion is shared for several reasons, including the objective of minimizing the environmental impacts of the treatment facilities (particularly to cut, fill, or flood riparian areas, or impact downstream channel stability), the impact to the surrounding communities that would result during the construction of such facilities, and the potential threat to downstream communities posed by such structures given the seismic activity in the region and during floods.

Regulatory Input and Guidance—The Panel received input and guidance from various regulatory entities such as the RWQCB. A Panel member, Dr. Michael Stenstrom, P.E., provided status reports to the Board at meetings in March and April in 2008, while the full Panel presented to the Board in June, 2008.

Site Inspections – The Panel inspected the site on several occasions to gain familiarity with the watersheds and their drainages, and to scope ENTS opportunities in the field.

The site visits included meeting with the Sage Ranch management as well as NASA representatives.

WebEx Briefings— Members of the Geosyntec project team routinely held Web-based interactive briefings for the Panel. The purpose of the briefings, which occurred approximately every two to four weeks during January through May, 2008, was to inform Panel members of the most recent results of their directed project studies and to serve as a forum for future direction for study and design efforts. Representatives from Boeing also periodically provided information to the Panel members during the WebEx briefings. Technical questions raised by Panel members were frequently forwarded to the Geosyntec staff who were tasked with gathering the additional information, data, or model simulations as requested.

BMP Performance Information—Selection of natural Best Management Practices (BMPs) for use in the 008 and 009 basins was based in part on BMP performance data taken from the *International BMP Database* (www.BMPDatabase.org). The database has a quantitative assessment tool to evaluate the potential effectiveness of different types of BMPs for removing a variety of contaminants over a range of conditions.

NPDES Stormwater Quality Monitoring Data – Data compiled by MWH were considered by the Panel to assess historic and existing stormwater quality conditions relative to Permit limits.

Outfall Discharge Monitoring Data for Model Calibration—Stream flow monitoring data used to calibrate the hydrologic models of the 008 and 009 watersheds were reviewed by Panel members.

BMPs Employed for Other Outfalls—Stormwater BMPs employed at other SSFL outfalls were visited by Panel members during field trips at the site, and design information and water quality monitoring performance data from these systems were reviewed.

Previous Analyses Prepared Prior to the Formation of the Panel—Studies and data from the SSFL that are relevant for stormwater quality management in basins 008 and 009 that were prepared prior to the formation of the Panel provided useful analyses and data summaries. Examples of these reports include the MWH design storm memo (dated March 29, 2007), the Design Storm Task Force report for water quality in the Los Angeles region (dated October 1, 2001), the Flow Science report on background constituent levels in stormwater (dated May 1, 2007), quarterly NPDES monitoring reports, and the MWH media filtration pilot testing report (dated October 2006).

Stormwater NPDES Permits for Other Industrial Sites—To assess the regulatory requirements of other industries and facilities compared to the SSFL permit requirements, a range of industrial NPDES stormwater permits were reviewed, some of which were for facilities that shared similar characteristics with the SSFL.

3.0 GUIDING PRINCIPLES

Guiding principles were adopted by the Panel for use in planning, evaluating and selecting the appropriate ENTS facilities for the 008 and 009 basins. These principles are based on specific objectives identified for the ENTS treatment facilities and take into consideration the background information and unique constraints of the site. The intent of the principles is to develop treatment systems that:

- Meet the NPDES numeric permit limits to the maximum extent feasible.
- Utilize "natural" systems in accordance with the Cease and Desist Order.
- Treat the maximum amount of runoff feasible given the constraints of the site.
- Are consistent with the expected future open space/park land use of the site.
- Minimize impacts to riparian corridors and other natural resources.
- Are based on the specific fate and transport characteristics of the contaminants being treated.
- Do not exacerbate the migration of contaminants in groundwater.
- Take into consideration the long-term operation and maintenance requirements of the treatment systems.
- Do not create, in and of themselves, a significant added threat to human health and safety, given the characteristics of the site.
- Utilize pollutant source controls in the overall treatment process.
- Treat runoff at the subregional scale and at critical source locations.
- Utilize all feasible areas for volume reduction and treatment.
- Combine treatment controls in a series, or 'treatment train," to treat runoff for multiple constituents and to protect downstream control measures.
- Reduce peak flows to optimize treatment.
- Include "polishing" enhancements (media additions, BMP soils amendments, etc.)

4.0 CONCEPTUAL DESIGN METHODOLOGY

After the relevant background information was reviewed, conceptual designs for the ENTS facilities were developed, taking into consideration the treatment system objectives and site constraints described earlier. The conceptual design methodology involved six major steps:

Step 1: Identify Design Storm—A design storm was identified for use as the basis to conceptually determine the size requirements of the treatment systems and to assess the resulting compliance with numeric permit limits. An important compliance consideration is the use of the design storm to determine whether enforceable limits or benchmarks apply for a given monitored storm event.

The Panel recommended that the design storm be 2.5 inches in 24 hours or peak one-hour intensity of 0.6 inches per hour. The 2.5 inch storm corresponds to a 1-year 24-hour event. This storm size was recommended based on the premise that the resulting treatment system would achieve a desired target of approximately 90 percent runoff volume capture and treatment. The system would treat all runoff from approximately 95

percent of all storms that occur at the site and provide significant partial treatment of the remaining 5 percent of all storms.

Step 2: Identify Suitable Locations for ENTS Facilities— Essentially every available parcel of relatively flat land was evaluated as a potential site for an ENTS facility if the land was located downstream from potentially contaminated areas, built-upon areas, or downstream of medium to large drainages in the 008 and 009 basins. Locations were reviewed using mapping and were also inspected during field trips conducted by the Panel.

Based on the conceptual treatment system sizing requirements identified in Step 1, initial suitable locations were identified for ENTS's. Sites were ultimately identified as potentially suitable locations based on system volume capture requirements coupled with specific site space constraints while considering the guiding principles such as the location of groundwater contaminant plumes, locations of riparian corridors, assured access, ability to serve as part of a "treatment train" (series of BMPs) and other factors.

Step 3: Evaluate Hydrologic Model Results for ENTS Facilities—For the different ENTS facilities identified and initially sited in Step 2, hydrologic models were used to assess the long-term volume capture (flows receiving desired treatment) for each ENTS and for the system as a whole, based on continuous long-term hydrologic simulations. The Panel and consultants to the Panel performed and reviewed treatability testing and BMP performance research to select appropriate unit operations for the range of pollutants found at the site and to optimize the ENTS conceptual designs.

Step 4: Evaluate Alternative Configurations of ENTS Facilities—The results from Step 3 were used to evaluate the ENTS facilities in terms of alternative sizing, configuration, and operation. An iterative process was used to optimize the ENTS facility designs, making changes such as deepening detention basins, to maximize the volume of runoff treated. ENTS facilities were designed in series to enhance treatment. Bioretention facilities were designed to maximize contact time with the treatment media.

Step 5: Finalize Design Storm and ENTS Concepts—Based on an evaluation of the information compiled in the prior steps, including assessing the initial ENTS performance modeling results for long-term average volume capture, a final design storm was identified (2.5 inches in 24-hours or 0.6 inches in 1-hour, a 1-year return interval event) and specific design concepts were modified as feasible to adjust the volume capture.

Step 6: Refine ENTS Designs—For each of the conceptual ENTS facility designs identified in Step 5, the designs were further evaluated and refined, taking into consideration factors such as outlet design, dam safety, facility armoring for large storm events, access, maintenance, footprints relative to existing stands of oak trees, and a variety of design details.

5.0 ENTS ALTERNATIVES EVALUATED

Based on the approach described above, the Panel, with support from Geosyntec Consultants worked closely to prepare the conceptual designs for the ENTS facilities for subbasins 008 and 009, as shown in Figures 1A and 1B. Figures 1A and 1B indicate there are over three dozen ENTS treatment facilities proposed in these two subbasins, and that they fall into the following categories.

Table 1
ENTS Types in Subbasins 008 and 009, as of June, 2008*

Abbreviation	Term Abbreviated	Definition
AR	Asphalt Removal	Asphalt removal projects reduce the amount impervious surface in the watersheds and restore paved areas to natural conditions. These projects involve removing the existing pavement and subgrade, restoring the exposed topsoil, and stabilizing the area with erosion and sediment controls until natural vegetation has become established.
BIO	Biological Treatment	These facilities consist of bioswales, bioretention, filter strips or other stormwater treatment facilities that incorporate biological processes as part of the overall treatment mechanism. Some are combined with upstream storage to enhance settling and meter flows through the biological systems (see TT below).
CM	Culvert Maintenance	Culvert maintenance projects are designed to improve existing hydraulics for increasing treatment, reduce erosion, enhance water quality, help to desynchronize flows and improve the overall structural conditions and safety of existing culverts.
GC	Grade Control	Instream grade controls reduce channel–flow velocities, reduce channel erosion and improve slope stability. Grade controls can be rock berms, check dams or hardened transitions at grade breaks.
RR	Road Rehabilitation	Road rehabilitation projects are targeted at existing roads that may be contributing to erosion and sediment loading. These projects employ distributed best management practices to reduce concentrated flows, scour and erosion. They are targeted to specific road segments.
TT	Treatment Train	Multiple physical, biological or combined stormwater treatment facilities or unit processes, in series. Treatment train systems include a pretreatment and/or flow equalization process followed by one or more polishing processes.

*Note: All work at conceptual design level.

To illustrate the application of the alternatives generation and evaluation process described in the previous sections of this white paper, the following text presents major considerations and design steps associated with the following representative ENTS facilities:

1. Liquid oxygen (LOX) facility (Section 5.1)
2. Culvert modifications (Section 5.2)

3. Biological treatment facilities (Section 5.3)
4. Ash pile (Section 5.4)

5.1 LOX ENTS

The strategic importance of the LOX site for stormwater quality management in the 009 subbasin became apparent to the Panel during their first field inspection and in-person meeting, in January, 2008, due to the following factors (see Figure 2 for perspective):

- This is the largest previously disturbed area (i.e., vegetation is minimal and significantly impacted) that is relatively flat in the 008 or 009 watersheds.

- The site is located relatively close to the 009 Outfall (i.e., there is substantial watershed area upstream from this site and it is relatively close to the NPDES compliance monitoring location).

- The site is located at the confluence of drainage from the off-site Sage Ranch area and onsite runoff.

- This reach of the 009 stream channel upstream and adjacent to the site is severely eroding, and in need of stabilization. Thus, an ENTS in this location could both stabilize a critical reach of channel and provide pollutant removal from upgradient runoff.

- Due to the nature of the stream channel, riparian zone, and side slopes downslope from the LOX site (steep canyon with well-defined riparian corridor and many trees that could not be disturbed without large impacts), the LOX represents the last large area that is suitable for treatment upstream from the 009 outfall.

- Boeing officials indicated to the panel that the LOX site would require extensive remediation under RCRA, which would involve tens of thousands cubic yards of earthwork. The panel's view has been if earthwork of this magnitude is necessary, this should be capitalized on to provide stormwater quality benefits (which would also require significant excavation).

Figure 2 shows the most current (as of June, 2008) conceptual design for the LOX facility. As shown in Figure 2, the basic approach with the LOX ENTS treatment train (TT) is to provide sedimentation basins for both off-site inflows from Sage Ranch and from the upper 009 watershed, followed by biofiltration prior to discharge into the existing channel downgradient (to the west of) LOX. Multiple alternatives have been conceptualized, modeled, evaluated and modified to arrive at the version shown in Figure 2. There has been extensive interaction between the Geosyntec design team and members of the Panel regarding the multiple alternatives evaluated in this location.

The earliest versions of the LOX facility were "off stream" and located to the north of the existing stream channel. However, through field meeting discussions with members of the Panel, it became clear that the feasibility of "floodplain options" (or "on stream" options) should also be evaluated. The advantages and disadvantages of off-stream versus on-stream facilities were carefully evaluated. For example, a disadvantage with an on-line facility is that it will periodically be subjected to large flood flows, which has implications regarding sediment loading, embankment safety, spillway requirements, structural design, maintenance frequency and other factors. By contrast, the selected on-stream facility offers significant advantages including, as examples:

- The stream channel through the site is experiencing serious erosion, which would be addressed because the channel is integrated into the facility.

- There is no need to divert stream flows with heavy sediment loads into an off-stream facility, which would be problematic from the standpoint of sediment blockage of the diversion and long-term maintenance of the diversion structure. A major aspect of the LOX alternatives analysis centered on alternative diversion schemes to convey channel flows into off-stream LOX ENTS facilities. These involved various diversion dam and flow splitter configurations and closed conduit conveyances, with variable sizes, geometries, slopes and other factors.

- The balance between excavation (cut) and fill at this site can be better optimized with an on-stream facility than an off-stream facility.

- Greater sediment basin volume and bioretention area (and therefore greater volume capture and treatment) was possible with this alternative.

Multiple LOX alternatives were modeled using the continuous SWMM hydrologic simulation model. The design process for the LOX ENTS, as well as the other ENTSs depicted on Figures 1A and 1B, involved an iterative process between hydrologic modeling (calculated volume capture and treatment) and design characteristics (surface area, depth, side slopes, sizing of hydraulic structures, detention time, etc.). For example, hydrologic modeling indicated that early LOX concepts were not attaining the objective of capturing and treating 90 percent of the average annual runoff volume. As a result, the volumes of the sedimentation and bioretention basins were increased. Subsequent modeling indicated that the 90-percent criterion was still not being attained, so the size of the upgradient treatment train No. 5 (TT 5 on Figure 1A) volume was increased to assist in reducing incoming flow rates. When this modification was still not adequate, additional culvert modifications were added into the plan to further reduce flow rates and were then modeled. Although this package of additions and modifications came close to the 90-percent volume capture/treatment criterion, subsequent modeling showed that more modifications were necessary. Upstream from the LOX ENTS, it was not feasible to develop additional water quality capture volume, so the target residence time in the LOX sedimentation basins was reduced from 72 hours to 24 hours, which accomplished the objective without significantly compromising the probable performance of the facility

(TSS removal was modeled for these drain time scenarios via settling theory and using site specific particle size distribution data). A recent adjustment has been to drop one retention cell at LOX to save a stand of oak trees in the channel. These steps are indicative of the iterative hydrologic modeling/design modification and optimization process that has occurred for the LOX ENTS along with the other facilities depicted on Figures 1A and 1B.

During the LOX alternatives evaluation process, many additional issues arose that were investigated and accounted for. For example, members of the panel asked whether it would be feasible to intercept runoff from Sage Ranch and divert it around (to the north of) the LOX facility. After reconnaissance-level evaluation, this approach was eliminated from further evaluation due to the potential for significant environmental impacts and severe construction constraints (a bypass channel or pipeline would need to be constructed on steep hillsides and a massive energy dissipater would be necessary to reduce impacts to the 009 channel of concentrated discharges from Sage Ranch). The 009 channel is eroding and north tributaries are headcutting on the eastern (upstream) side of the proposed LOX ENTS. Consequently, the facility has been designed to address these areas of instability. Similarly, the design has accounted for the fact that LOX discharges could potentially erode the downstream 009 channel in a steep canyon setting. Thus, a significant energy dissipater will be provided at the piped outlet from the downslope biorention cell as well as for overflows (for stormflows greater than the design capacity.

A constraint with the LOX ENTS is that NASA presently owns the property and must approve of any future use of the site.

Because of the importance and characteristics of the LOX site, the LOX ENTS example is illustrative of the multifaceted nature of the alternatives formulation, evaluation and selection process that has been utilized to date to generate the proposed facilities shown in Figures 1A and 1B.

5.2 Culvert Modifications

Consistent with sound stormwater quality management practice, from the outset of its involvement, Panel members have emphasized the importance of utilizing all practical locations for ENTS's and of desynchronizing flows (under normal circumstances the Panel would also have emphasized the importance of maximizing infiltration, but opportunities are limited in the 008/009 subbasins due to contaminated groundwater). In the course of generating alternatives for consideration, it became apparent that there were multiple culverts associated with roadway embankments on the SSFL and on the adjoining Sage Ranch property which might lend themselves to modification, to create storage and treatment facilities. Subsequent investigations determined that culvert modifications could be implemented in many locations to create storage, desynchronize flows, integrate bioretention to promote pollutant removal, enhance the structural integrity of existing culverts and reduce downstream channel erosion. Geosyntec and the Panel identified onsite and offsite (Sage Ranch) culverts that might be suitable for

retrofitting into ENTS facilities. Panel members and the Geosyntec design team recognized that multiple alternatives could potentially be used for retrofitting culverts beneath roadway embankments, related to such aspects as:

- Alternative forms of "risers" that could be attached to existing culverts.
- Replacing existing culvert pipes versus "slip lining" to restore or protect the structural integrity of the culverts.
- Strategies for improving the structural integrity of existing roads that cross the culverts.
- Handling long-term sediment inflows in the storage areas upslope from the roadway embankments.
- Integrating bioretention cells into these facilities, and the host of design questions that arise in this regard (see Section 5.3).
- Evaluating the implications of large storms overtopping the roadway embankments.

Figure 1B indicates that culvert modifications are planned in approximately one dozen locations in the 009 subbasin.

5.3 Biological Treatment Facilities

Figures 1A and 1B indicate that there are presently 7 proposed biological treatment facilities and an additional 6 treatment trains in the 009 watershed that also employ biological treatment in part of the treatment train. These ENTS locations and design characteristics are the result of a comprehensive alternatives evaluation process, relative to both defining suitable locations for this class of ENTS's and to selecting optimal conceptual design criteria. Representative factors that have influenced the selection and characteristics of biological treatment facilities include:

- Defining suitable locations, given such considerations as the nature of upgradient pollutant sources; type of proposed ENTS facilities; anticipated incoming sediment load; presence of contaminated soils and/or groundwater; projected inflow regime; topography; soils; slopes; existing vegetation; and long-term access.
- Optimizing detention times within treatment trains to meter flow through biological systems, given the competing objectives of treating the largest practical amount of runoff versus providing a target retention time of 72 hours (to maximize pollutant removal).
- Selecting the most appropriate mix of plant species.

- Identifying the optimal soil mixtures, given specific pollutant types and performance objectives. Soil layers in the biological treatment facilities will consist of a mixture of sand, organic material, and inorganic components with a total porosity range of between 35 percent and 55 percent and a saturated hydraulic conductivity of at least 6 inches/hour. Various combinations of soil mixtures are being evaluated by the Panel with Geosyntech assistance including, for example: filter sand; peat moss; activated carbon; bone char; and manganese-coated zeolite. Potential media mixtures will be tested under simulated operational conditions to confirm that the media will not contribute constituents of concern to the treated flow.

- Long-term operation and maintenance considerations are very important for biological treatment facilities, particularly questions related to the frequency of soil media removal and disposal.

5.4 Ash Pile

The Panel has identified the Ash Pile location, on the west side of the 009 watershed, as strategically important because there is a substantial RFI area upstream from it, slopes are relatively mild, and the site is relatively large. Figures 3 and 4 depict the facilities that are proposed in this location, including a flow spreading channel, bioretention areas and a bioswale. Many alternatives were evaluated in this location. For example, initial concepts envisioned a single ENTS here, but as the conceptual design process evolved, it became clear that a "split" drainage approach would be optimal. Multiple ENTS "footprints" were explored to minimize impacts to stands of oak trees and other types of vegetation. A significant feasibility factor in this location is the presence of contaminated soils and groundwater. Similar to the situation at the LOX site and other sites where there is known soil and/or groundwater contamination, members of the Panel and Geosyntec interacted with representatives of Boeing and remediation consultants who have characterized site conditions.

5.5 Dam and Treatment Plant Alternative

An alternative that was evaluated but ultimately eliminated from further consideration involved construction of dams and stormwater treatment facilities at the 008 and 009 outfalls. While appearing to be logical in theory, this alternative was rejected for the following reasons:

- Large dams would be required to store the targeted volume capture because of the narrow widths of the canyons at the proposed locations of the dams.

- A dam and treatment facility system is not consistent with the direction given in the Cease and Desist Order which specifies ENTS facilities for the 008 and 009 subbasins, not large detention structures that cause major environmental impacts and require pumping to active treatment systems.

- The seismic potential for the region makes large dam structures less attractive, particularly given the size of the population that resides immediately downgradient from the proposed dam site.

- The lack of available space for treatment systems adjacent to the dams and reservoirs would necessitate the construction of pump stations and relatively long pipelines to transport water to the treatment facilities. The length of the new pipelines would cause significant soil disturbance. In addition, a treatment approach that relies on pumping is not consistent with the natural treatment system strategy specified in the Cease and Desist Order.

- The permitting time required for dam and treatment plant systems (as required by CEQA, etc.) would delay the mandatory schedule for having operational treatment systems in place.

6.0 SUMMARY AND CONCLUSIONS

It is the Panel's intent that the resulting overall recommended stormwater program for the outfall 008 and 009 watersheds will result in a sustainable set of controls that go well beyond the standard practice for stormwater treatment systems nationally, while also protecting the natural characteristics and values of the watersheds. The Panel is working to develop a system of ENTS facilities that:

- Is designed to meet the numerical effluent limits established by the RWQCB to the extent feasible, within the practical limits of the ENTS technology, by reducing both the mass loading and concentration of water quality constituents.

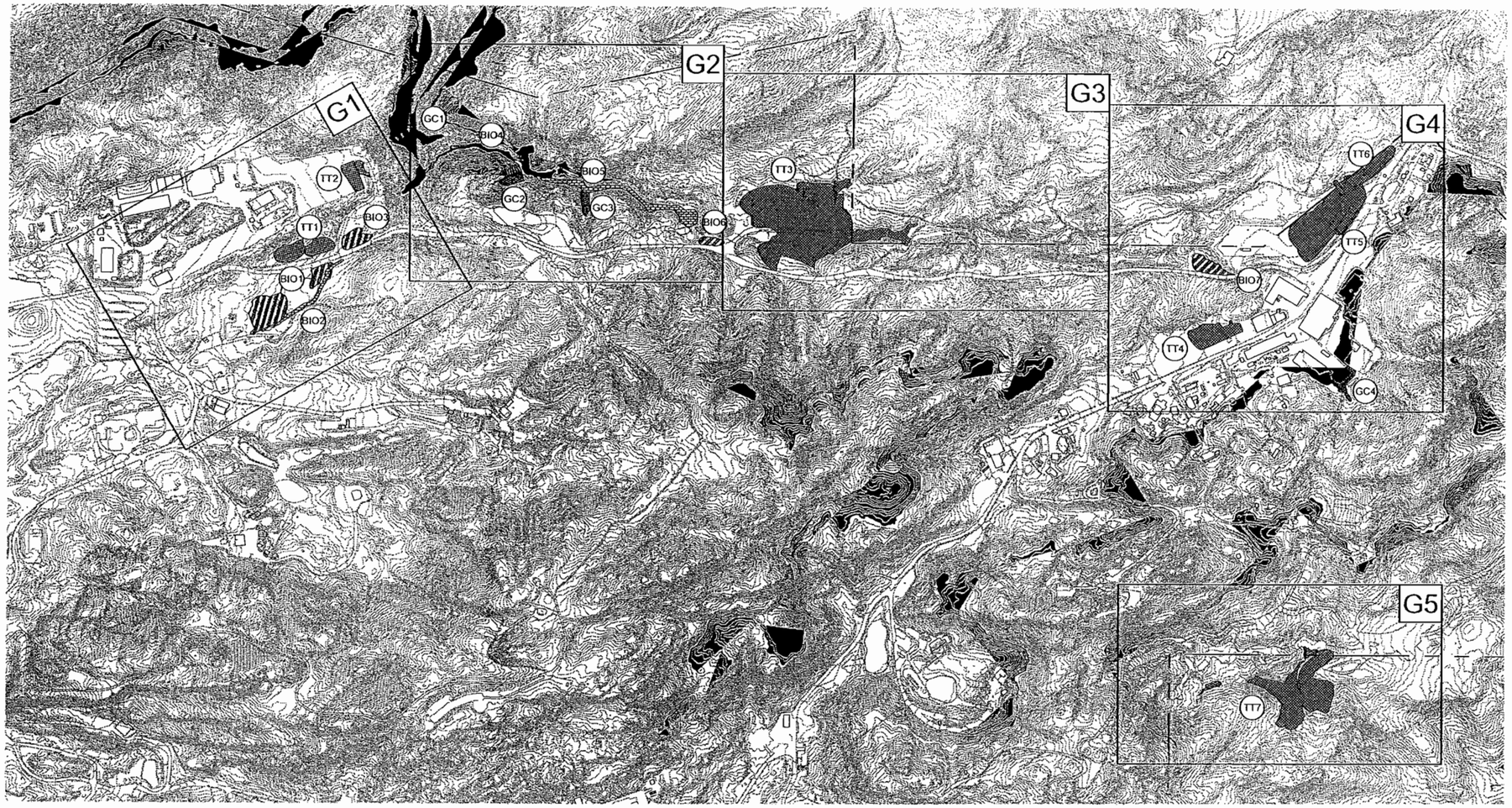
- Is protective to downstream residents and the environment

- Maintains the natural site conditions and ecological functions

- Maximizes the spatial opportunities to construct ENTS based on the site's constraints and implementation feasibility considerations.

A single stormwater control facility cannot feasibly be constructed at any specific location in the 009 subbasin because it would require a large dam and overflow structure and impose significant public safety and environmental impacts. As a result, the Panel alternatively recommends that water quality be achieved via multiple distributed ENTS facilities, source controls, and channel stabilization BMPs.

The ENTS facilities are viewed as temporary projects that will be kept in place while the ongoing environmental remediation activities at SSFL are occurring.



KEY MAP

LEGEND

730 — EXISTING GROUND CONTOUR (FEET)

— — — PROPERTY LINE

CM8 ENT INDENTIFIER

N

0 800' 1600'

SCALE IN FEET

Geosyntec consultants
3990 OLD TOWN AVE., SUITE B-101
SAN DIEGO, CALIFORNIA 92110 USA
PHONE: 619.297.1530.

BOEING
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

TITLE: GENERAL ENTS KEY

PROJECT: BOEING SSFL – WATERSHEDS 008 AND 009
ENTS – FINAL CONCEPTUAL DESIGNS

DESIGN BY:	JH/NJ	REVIEWED BY:	ES	DATE:	JUNE 2008	DRAWING:	G0-A
DRAWN BY:	BJP	APPROVED BY:	BS	PROJ. NO.:	SB0363L		

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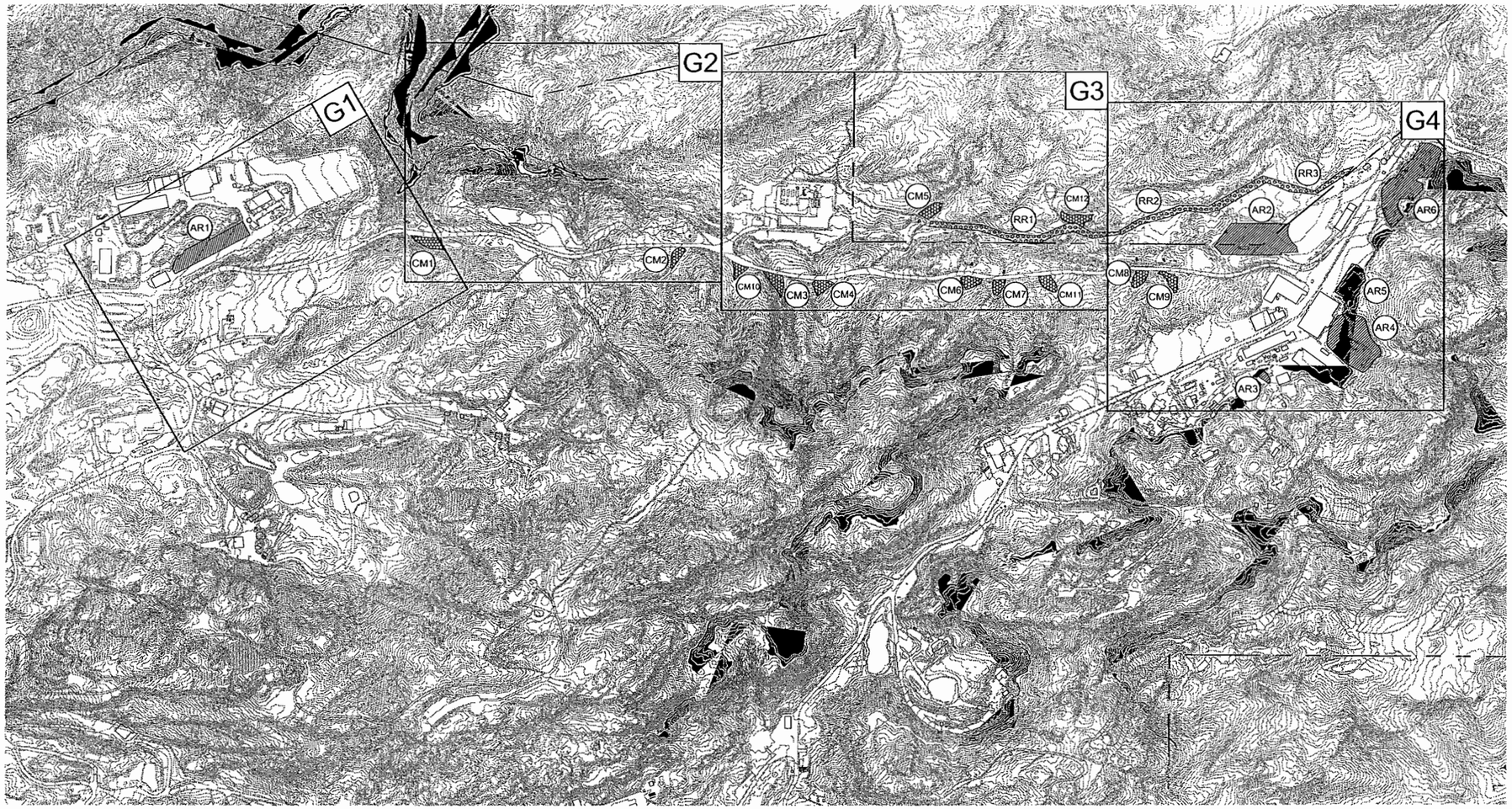
Figure 1A



KEY MAP

LEGEND

730 EXISTING GROUND CONTOUR (FEET)

PROPERTY LINE

(CM8) ENT INDENTIFIER

N

0 800' 1600'

SCALE IN FEET

Geosyntec consultants
3990 OLD TOWN AVE., SUITE B-101
SAN DIEGO, CALIFORNIA 92110 USA
PHONE: 619.297.1530.

BOEING
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

TITLE: GENERAL SWMA KEY

PROJECT: BOEING SSFL – WATERSHEDS 008 AND 009
SWMA – FINAL CONCEPTUAL DESIGNS

DESIGN BY: JH/NJ	REVIEWED BY: ES	DATE: JUNE 2008	DRAWING:	
DRAWN BY: BJP	APPROVED BY: BS	PROJ. NO.: SB0363L		G0-B

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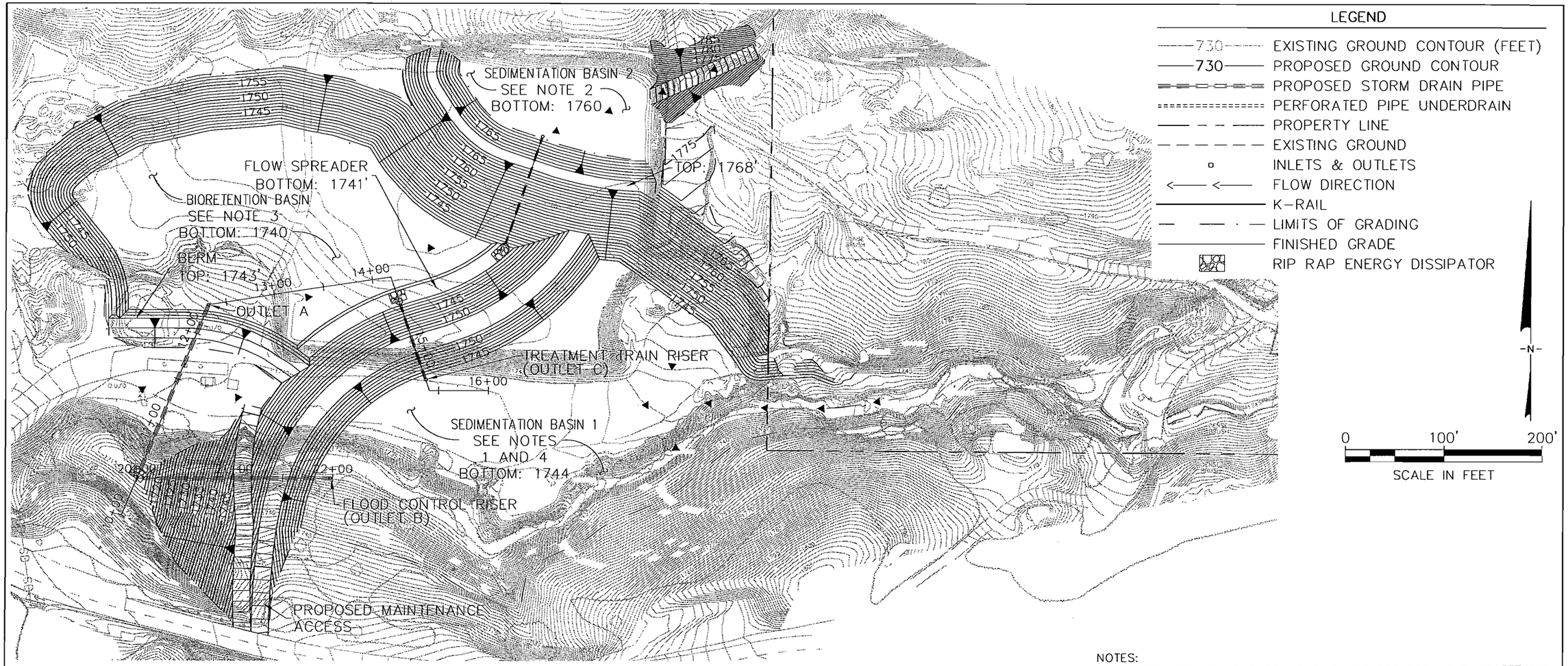
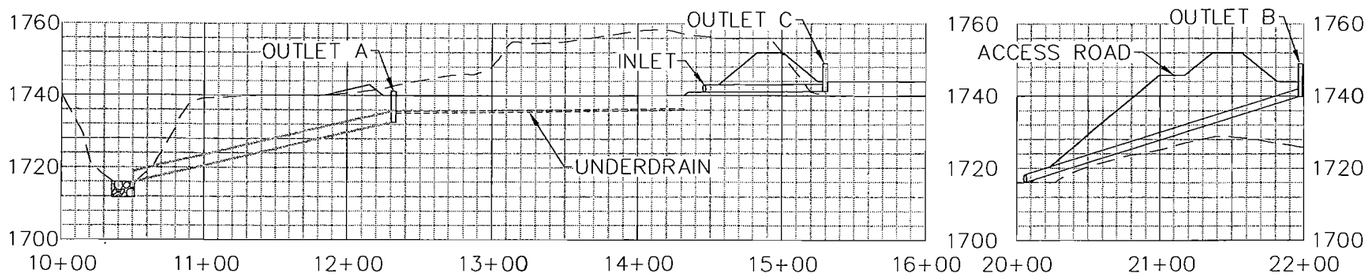
Figure 1B



PLAN VIEW



PROFILE
SCALE: 1"=40'

NOTES:
1. CONSTRUCT SEDIMENTATION BASINS 1&2 PER DETAILS ON SHEET D13.
2. SEDIMENTATION BASIN 2 CONVEYS THE OFF-SITE DRAINAGE TO THE BIORETENTION BASIN.
3. CONSTRUCT BIORETENTION BASIN PER DETAILS ON SHEET D3. UNDERDRAIN PIPE NOT SHOWN IN PLAN VIEW FOR CLARITY. PIPE LAYOUT WILL BE SHOWN ON DETAILED DESIGN DRAWINGS.
4. THE STORAGE VOLUME FOR SEDIMENT BASIN 1 DOES NOT EXCEED 15 ACRE-FT.

Geosyntec consultants
3990 OLD TOWN AVE., SUITE B-101
SAN DIEGO, CALIFORNIA 92110 USA
PHONE: 619.297.1530.

BOEING
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

TITLE: TREATMENT TRAIN

PROJECT: BOEING SSFL – WATERSHEDS 008 AND 009 ENTS – FINAL CONCEPTUAL DESIGNS

DESIGN BY: JH/NJ	REVIEWED BY: ES	DATE: JUNE 2008	DRAWING:
DRAWN BY: BJP	APPROVED BY: BS	PROJ. NO.: SB0363L	TT3

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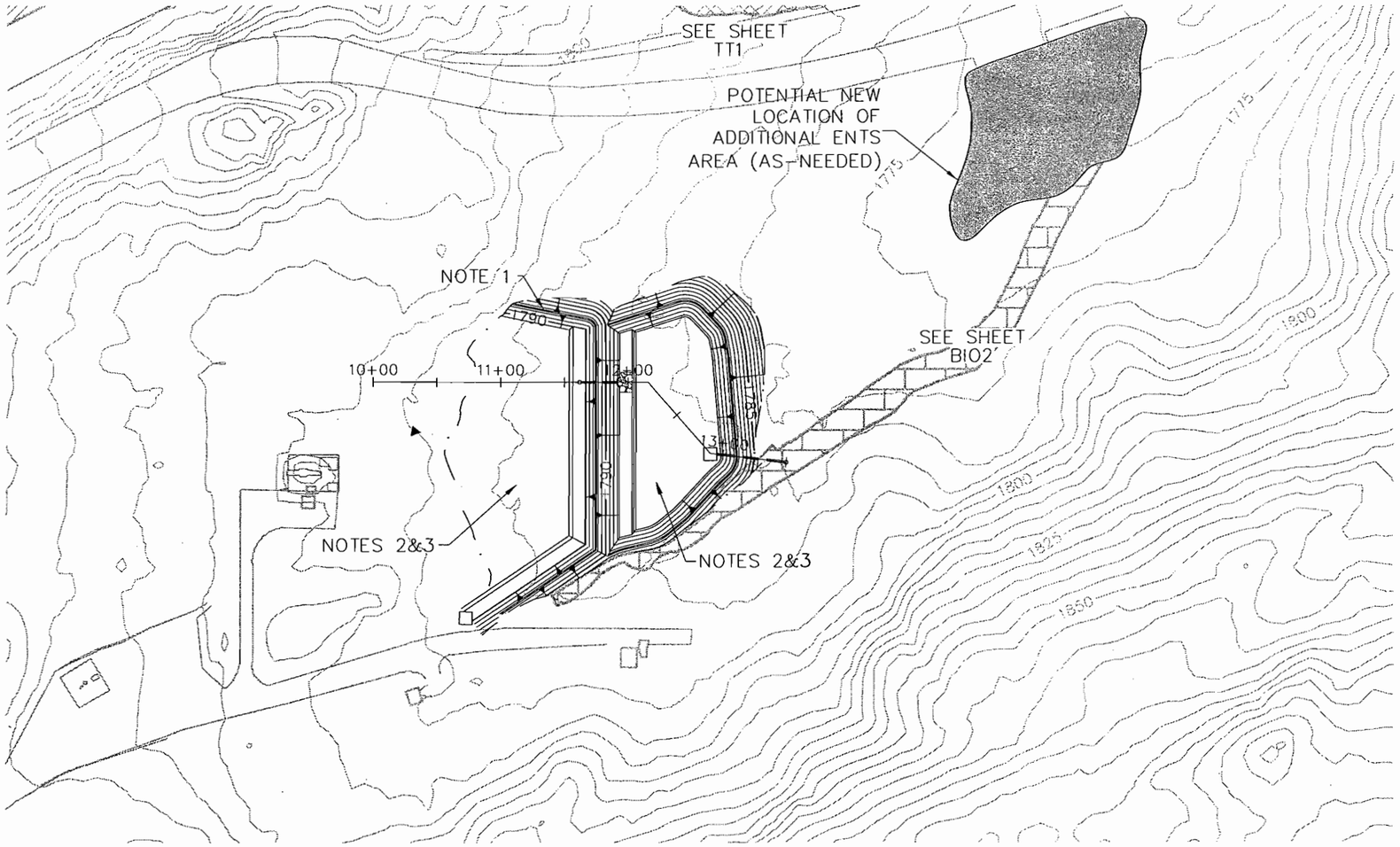
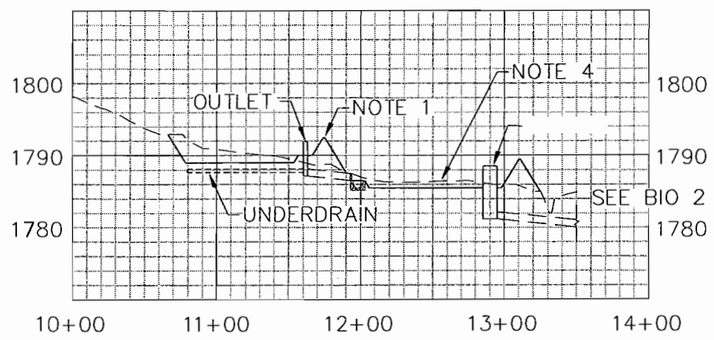
Figure 2



PLAN VIEW



PROFILE VIEW
VERT. SCALE: 1"=20'

LEGEND

- 730 — EXISTING GROUND CONTOUR (FEET)
- 730 — PROPOSED GROUND CONTOUR
- EXISTING GROUND
- PROPOSED STORM DRAIN PIPE
- EXISTING STORM DRAIN PIPE
- LIMITS OF GRADING
- FINISHED GRADE
- RIP RAP ENERGY DISSIPATOR
- FLOW DIRECTION

N

0 100' 200'
SCALE IN FEET

NOTES:
1. CONSTRUCT PERVIOUS (FLOW SPREADING) BERM PER DETAIL D10 (LOOSELY PLACED WITHOUT MORTAR).
2. CONSTRUCT A BIORETENTION AREA PER DETAIL D3. UNDERDRAIN PIPE NOT SHOWN IN PLAN VIEW FOR CLARITY. UNDERDRAIN PIPE LAYOUT WILL BE SHOWN ON DETAILED DESIGN SUBMITTAL.
3. DUE TO THE TOPOGRAPHIC RESOLUTION THE LOCATION OF THIS BIORETENTION IS APPROXIMATE. SPECIFIC LOCATIONS AND ELEVATIONS WILL BE PROVIDED IN DETAILED DESIGN DRAWINGS.
4. UTILITY CONFLICTS ARE NOT SHOWN AND WILL BE REDESIGNED (AS NECESSARY) WHILE MAINTAINING THE INTENDED TREATMENT FACILITY.
5. RISER PIPE IS INTENDED TO FUNCTION AS A LOW FLOW CONVEYANCE AS WELL AS AN EMERGENCY SPILLWAY.

Geosyntec consultants
3990 OLD TOWN AVE., SUITE B-101
SAN DIEGO, CALIFORNIA 92110 USA
PHONE: 619.297.1530.

BOEING
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

TITLE: BIORETENTION

PROJECT: BOEING SSFL – WATERSHEDS 008 AND 009
ENTS – FINAL CONCEPTUAL DESIGNS

DESIGN BY:	JH/NJ	REVIEWED BY:	ES	DATE: JUNE 2008	DRAWING: BIO1
DRAWN BY:	JA/BP	APPROVED BY:	BS	PROJ. NO.: SB0363L	

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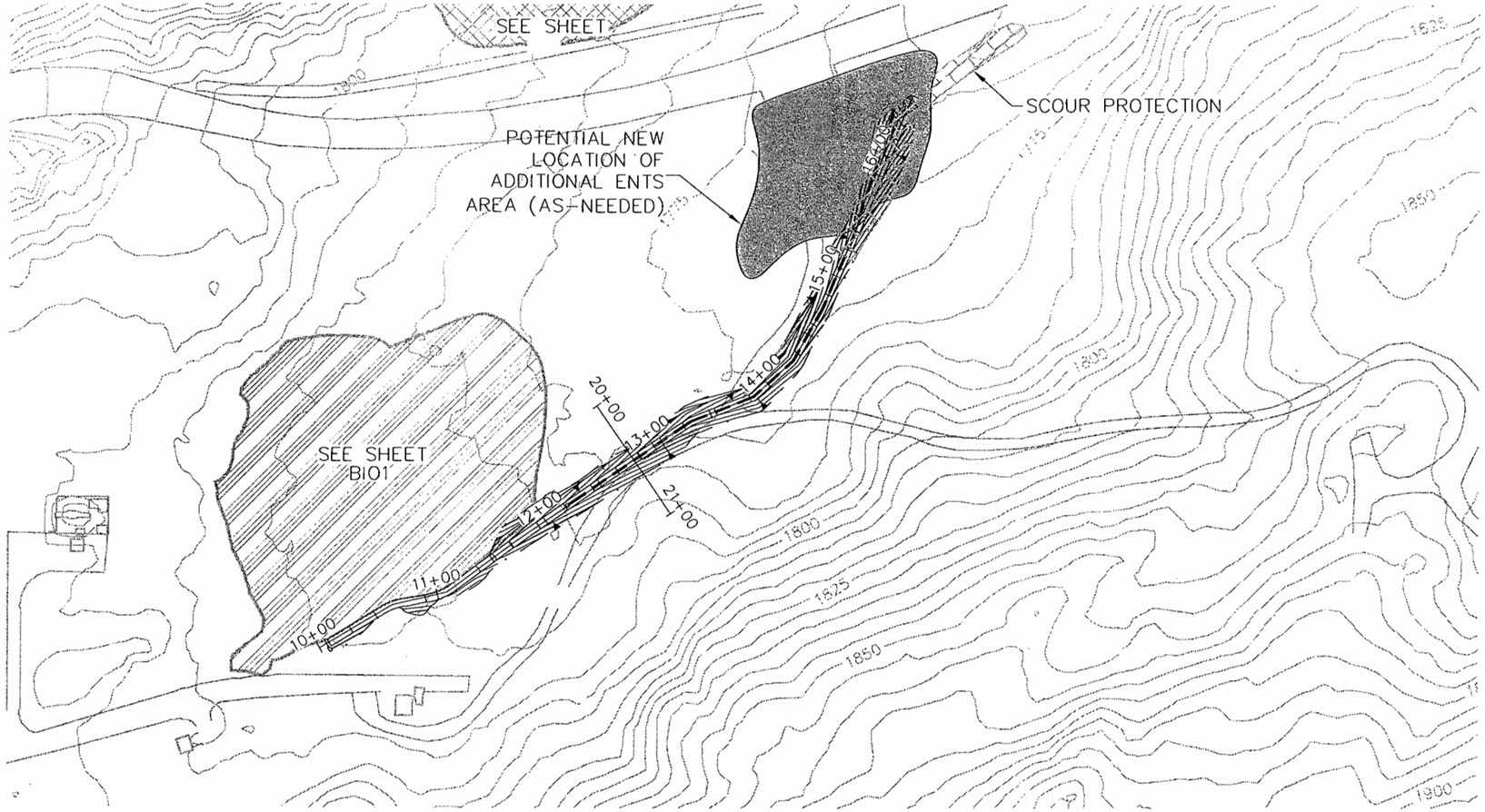
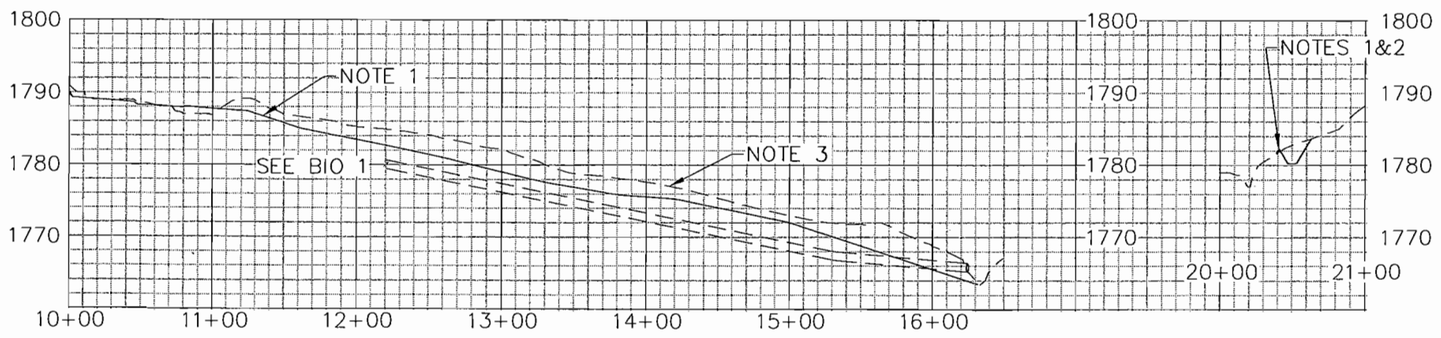
Figure 3



PLAN VIEW



PROFILE VIEW
VERT. SCALE: 1"=20'

LEGEND

- 730 EXISTING GROUND CONTOUR (FEET)
- 730 PROPOSED GROUND CONTOUR
- EXISTING GROUND
- LIMITS OF GRADING
- FINISHED GRADE
- FLOW DIRECTION

N

0 100' 200'
SCALE IN FEET

NOTES:
1. CONVERT EXISTING ROADWAY INTO A BIOSWALE PER DETAIL D5.
2. DUE TO THE TOPOGRAPHIC RESOLUTION THE LOCATION OF THIS BIOSWALE IS APPROXIMATE. SPECIFIC LOCATIONS AND ELEVATIONS WILL BE PROVIDED IN DETAILED DESIGN DRAWINGS.
3. UTILITY CONFLICTS ARE NOT SHOWN AND WILL BE REDESIGNED (AS NECESSARY) WHILE MAINTAINING THE INTENDED TREATMENT FACILITY.
4. BIO1/BIO2 EFFLUENT, ROADWAY FLOWS, STREAM CHANNEL DISCHRAGE COLLECTION AND TRANSITION AREA. DESIGN OUTLET PER DETAIL D7 (CULVERT MAINTENANCE) OR EQUILVALENT. GRADING SHOWS THE ESTIMATED TRANSITION AREA AND IS SUBJECT TO REVISION BASED ON FIELD SURVEY.

Geosyntec consultants
3990 OLD TOWN AVE., SUITE B-101
SAN DIEGO, CALIFORNIA 92110 USA
PHONE: 619.297.1530.

BOEING
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

TITLE: BIOSWALE

PROJECT: BOEING SSFL – WATERSHEDS 008 AND 009
ENTS – FINAL CONCEPTUAL DESIGNS

DESIGN BY: JH/NJ	REVIEWED BY: ES	DATE: JUNE 2008	DRAWING:
DRAWN BY: JA/BP	APPROVED BY: BS	PROJ. NO.: SB0363L	BIO2

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Figure 4