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San Francisco Zoological Gardens
Infrastructure Master Plan

Final Report

City & County of San Francisco
Department of Public Works
San Francisco Zoological Gardens

K/J 930524.03
August 1995

Kennedy/Jenks Consultants, Inc. - AGS, Inc.
An Association

Kennedy/Jenks Consultants**Engineers and Scientists**

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25 August 1995

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Ms. Karen Kubick
City and County of San Francisco
Department of Public Works
30 Van Ness, 5th Floor
San Francisco, CA 94102

Ms. Marla Jurosek
San Francisco Zoological Gardens
1 Zoo Road
San Francisco, CA 94132

Subject: San Francisco Zoo Infrastructure Master Plan -- Final Report
K/J 930524 / AGS 920801

Dear Ms. Kubick and Ms. Jurosek:

Enclosed for your use is the San Francisco Zoo Infrastructure Master Plan Final Report. This revised report incorporates your comments on the December 1994 draft report and includes revised estimates of probable construction costs for the recommended infrastructure improvements.

An executive summary is provided to highlight the findings and recommendations for each utility system as well as provide a discussion on the overall implementation of the proposed improvements and their probable construction costs. For each system, a separate section is provided to discuss demands/flows, design criteria and assumptions, modeling assumptions, recommended facilities and their proposed implementation.

This final report also contains the following appendices:

- Approved Negative Declaration for the Infrastructure Project;
- AGS, Inc.'s Zoo Water Resource Feasibility Analysis Report dated September 1994; and
- AGS, Inc.'s Infrastructure Geotechnical Study Final Report dated June 1995.

For both the water and sewer systems, separate technical binders containing actual model runs and results have been prepared; these are available for your review upon request.

Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the system. The study is divided into two main parts: a theoretical analysis and an experimental evaluation.

The theoretical analysis is based on the principles of the system and the assumptions made in the design. It is used to predict the performance of the system under various conditions. The experimental evaluation is used to verify the results of the theoretical analysis and to determine the actual performance of the system.

The results of the study show that the proposed system has a significant impact on the performance of the system. The theoretical analysis predicts that the system will perform well under a wide range of conditions, and the experimental evaluation confirms this prediction.

The study also shows that the proposed system is robust and can handle a wide range of inputs. This is a significant advantage of the system, as it allows it to be used in a wide range of applications.

The results of the study are presented in the following sections. The first section presents the theoretical analysis, and the second section presents the experimental evaluation. The third section presents the conclusions of the study.

The study is organized as follows. Chapter 1 presents the introduction, Chapter 2 presents the theoretical analysis, Chapter 3 presents the experimental evaluation, Chapter 4 presents the conclusions, and Chapter 5 presents the references.

The study is a contribution to the field of system design and performance. It provides a detailed analysis of the proposed system and its performance, and it provides a basis for further research in this area.

The study is a valuable resource for researchers and practitioners in the field of system design and performance. It provides a detailed analysis of the proposed system and its performance, and it provides a basis for further research in this area.

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Ms. Karen Kubick
Ms. Marla Jurosek
25 August 1995
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We have enjoyed working with you on this Master Plan and look forward to our continued involvement with the project. Please call if you have any questions.

Very truly yours,

KENNEDY/JENKS CONSULTANTS

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**SAN FRANCISCO ZOOLOGICAL GARDENS:
INFRASTRUCTURE MASTER PLAN
FINAL REPORT**

Prepared for

***City and County of San Francisco
Department of Public Works
&
San Francisco Zoological Gardens***

Prepared by

***Kennedy/Jenks Consultants-
AGS, Inc., An Association***

***August 1995
K/J 930524***

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ABBREVIATIONS

AWWA	American Water Works Association
BMPs	Best Management Practices
BTU	British Thermal Unit
CFH	Cubic feet per hour
cfs	Cubic feet per second
CGS	Central Gravity Sewer
City	City of San Francisco
DWPS	Dry Weather Pump Station
ESP2	Earthquake Safety Program Bond Issue for City-Owned Facilities, Phase II
fps	Feet per second
gal	Gallons
gpd	Gallons per day
gpm	Gallons per minute
hrs	Hours
in	Inches
K/J	Kennedy/Jenks
kV	Kilovolt
kVA	Kilovolt Ampere
kW	Kilowatt
MBH	Thousand BTUs per hour
MSL	Mean Sea Level
NFPA	National Fire Protection Association
OER	City of San Francisco Office of Environmental Review
PacBell	Pacific Bell
PG&E	Pacific Gas and Electric
Portico	The Portico Group
psi	Pounds per square inch
PVC	Polyvinyl chloride
RPBP	Reduced pressure backflow preventer
SFWD	San Francisco Water Department
UFC	Uniform Fire Code
V	Volts
Zoo	San Francisco Zoological Gardens

SAN FRANCISCO ZOO INFRASTRUCTURE MASTER PLAN FINAL REPORT

EXECUTIVE SUMMARY

INTRODUCTION

Purpose of Infrastructure Master Plan

The San Francisco Zoo's underground utility systems (including water, sewer/drainage, electrical and natural gas) are extremely old and in poor condition. The 1989 Loma Prieta earthquake caused significant damage to the Zoo's aging utility systems resulting in a loss of services to Zoo facilities. These systems are in need of replacement to meet the current and future needs of Zoo staff, visitors and animals and to be brought to current seismic design and construction standards. In 1990, voters approved the Earthquake Safety Program Bond Issue for City-Owned Facilities (Phase II) for the replacement of underground utilities at the Zoo to address this need.

The purpose of the San Francisco Zoo Infrastructure Master Plan is to develop a "road map" which will be used to guide the planning, design and implementation of future Zoo infrastructure replacements and improvements. This Infrastructure Master Plan, which will be implemented by the City Department of Public Works, provides the framework for designing and constructing the infrastructure facilities required to serve both the current Zoo and the future Zoo.

Concurrently, The Portico Group, under contract with the Zoological Society, is in the process of developing an overall Master Plan for the Zoo, known as the San Francisco Zoological Gardens Master Plan (Zoo Master Plan), which will guide the planning, design and implementation of future Zoo exhibits and facilities. The preliminary recommendations of the Zoo Master Plan (Portico, 1994) have been considered and, as applicable, incorporated into this Infrastructure Master Plan. Continued coordination between the Zoo Master Plan and the Infrastructure Master Plan throughout the remainder of the planning phase, and into the design and construction phases, will be critical to the success of the Zoo's improvement projects.

Organization and Contents

This Infrastructure Master Plan is divided into four main sections:

- Potable, Groundwater and Reclaimed Water Systems;
- Combined Sewer/Drainage Systems;
- Electrical System and Communications Conduit; and
- Natural Gas System.

Each section of the Infrastructure Master Plan contains the design criteria and assumptions, anticipated demands/loads, recommended facilities, implementation plans and estimates of probable construction costs for each utility system. The Water Systems section provides this information for each of the Zoo's anticipated water supplies (potable, groundwater and reclaimed water).

Appendices to this Infrastructure Master Plan include the following:

- Approved Negative Declaration for the San Francisco Zoo Infrastructure Replacement;
- Zoo Groundwater Resource Feasibility Analysis and Well Destruction Issues; and
- Infrastructure Geotechnical Study for the San Francisco Zoological Gardens.

A summary of the general design philosophy utilized for each utility system, recommended facilities, implementation plan and schedule and probable construction costs are contained within this Executive Summary.

PLANNING PHILOSOPHY

The key concept in the planning of the Zoo's utility system improvements is the use of utility corridors. For this project, a utility corridor is defined as a common underground pathway for the installation of utilities, including water, sewer/drainage, electrical and natural gas systems. The alignment of these corridors has been planned to allow for easy access and maintenance in the future and to minimize disruption to the existing Zoo during construction.

Other goals of the Infrastructure Master Plan, which can be accomplished with the use of utility corridors, include the following:

- To minimize disruption of the existing Zoo animals, exhibits and facilities during construction, by: (1) establishing utility corridors; (2) phasing and sequencing of construction activities; and (3) temporarily habituating or relocating animals as needed;
- To plan the utility improvements so that they can be constructed within the next three or four years without causing major disruptions to existing Zoo exhibits and facilities and visitor use of the Zoo;
- To provide a utility system which, to the extent possible, is seismically-resistant and reliable during emergency conditions;

- To construct new backbone utility systems to allow for service connections to existing Zoo facilities;
- To locate proposed utility corridors and associated facilities to minimize visual and noise impacts to the Zoo animals and visitors; and
- To minimize future operation and maintenance costs.

RECOMMENDED FACILITIES

Water Systems

Background

The Zoo's current potable water and groundwater systems are deteriorated and in need of replacement in order to ensure a reliable water supply for Zoo operations. In the future, the Zoo will be provided with three separate water supplies:

- Potable water purchased from the City;
- Groundwater pumped from two new replacement wells at the Zoo; and
- Reclaimed water, when available, from the City's planned tertiary treatment plant.

Each of these supplies will have distinct uses within the future Zoo as shown in Table ES-1.

**TABLE ES-1
PROPOSED WATER USES**

Water Supply System	Proposed Water Uses
Potable Water	Human related uses (drinking, cafes, restrooms, etc.), animal drinking and to supply fire demands at hydrants and building sprinkler systems
Groundwater	Pool filling, washdown of animal areas, irrigation within exhibits, ornamental streams and filter backwashing of exhibit pools
Reclaimed Water	When available, will be used for general irrigation purposes

Initially, until reclaimed water becomes available, groundwater will be utilized to meet the Zoo's irrigation demands.

Recommended Facilities and Improvements

The following water supply facilities and improvements are recommended to serve the water needs of the existing and future Zoo. The locations of the proposed facilities and improvements are shown on Figures 1-8 and 1-9 in the Water Systems section.

Distribution System for Potable, Groundwater and Reclaimed Water

The potable, groundwater and reclaimed water distribution system will consist of 6-inch-diameter mains within looped utility corridors in the Zoo. Three water pipelines will be installed within each corridor with appropriate vertical and horizontal clearances; each pipeline will be of a different material and color to avoid accidental future cross-connections.

Potable Supply Connections

To increase the potable water flows from the City's system to the Zoo, it is recommended that the three existing 6-inch supply points from the City system be increased to 8-inch connections and that a new 10-inch supply point be established along Herbst Road.

Groundwater Wells

The existing Zoo wells are deteriorated and were damaged during the 1989 earthquake, necessitating the construction of two new replacement wells. One of the new wells will be the primary well and the other will be a standby. Each replacement well will be constructed to a depth of approximately 520 feet; the anticipated yield for each well is approximately 1,250 gallons per minute (gpm). Small pump houses will be provided for each well. Each well will, in the near-term, discharge to the Zoo's existing groundwater reservoir. Once the new groundwater reservoir is constructed (see below), the wells will discharge to it. A report on the Zoo's groundwater resources and the proposed construction of the new wells is provided in Appendix B.

Groundwater Reservoir

The Zoo's existing open reservoir, which has been fitted with a cover to mitigate operations and maintenance problems, will continue to serve the Zoo in the near-term. A new groundwater reservoir, anticipated to be a 390,000-gallon buried concrete reservoir, will be located just west of the current Zoo (beneath the planned Zoo parking lot).

Groundwater Booster Pump Station

The Zoo's existing groundwater booster pump station will continue serving the Zoo's groundwater needs in the near-term. Once the new groundwater reservoir is constructed, a new groundwater booster pump station will be built.

Sewer/Drainage System

Background

The Zoo's existing sewer/drainage system is deteriorated and inadequate to handle the Zoo's existing flows and projected future flows. Currently, the existing system backs up and causes localized flooding within the Zoo during high flow periods. Also, the existing system is incapable of resisting lateral forces from earthquakes.

Both existing and future flows consist of toilet flushing, exhibit washdown, pool drainage and stormwater flows. Future stormwater flows are anticipated to be somewhat higher than existing flows due to a larger Zoo area (expansion to the west and to the south) and larger impervious areas (primarily parking lots).

The design objective for the future combined sewer/drainage system for the Zoo is to drain all dry weather flows by gravity out of the Zoo and into the City's Westside Transport. The new system will have a wet weather lift station to handle large infrequent flow conditions during storm events when the Westside Transport levels rise.

The new system will also convey sanitary and storm flows from several areas upstream of the Zoo, including the Harding Park Golf Course, the Recreation Center for the Handicapped and the State National Guard Armory. These flows currently pass through the Zoo via the Harding Park sewer and other existing combined sewer lines within the Zoo.

Recommended Facilities and Improvements

The following sewer and drainage facilities are recommended to serve the sewer and drainage needs of the Zoo. The locations of the proposed facilities and improvements are shown on Figures 2-1 and 2-2 in the Sewer/Drainage Systems section.

Sewer Trunk Lines

The proposed sewer trunk lines will consist of a series of branches which will collect flows from exhibit laterals and convey flows by gravity to the northwest corner of the Zoo. In general, both sewer and drainage flows will be conveyed in the same pipeline; an exception is in the western part of the Zoo adjacent to the future parking lot where two separate lines, one smaller line for sewage flows and one larger line for drainage flows, are recommended to meet the design criteria due to slope limitations. An alternative to the use of two separate pipelines would be the use of a cunette pipe, which is a large pipe with a low flow channel; the use of such a pipe will be evaluated during the utility design phase.

Wet Weather Lift Station

The wet weather lift station will be located in the northwest corner of the Zoo (just east of the City's Westside Pump Station) and will pump flows to the Westside Transport during

high flow conditions. During low flow conditions, flows will bypass the pump station and flow by gravity to the Westside Transport.

Electrical System and Communications Conduit

Background

The Zoo's current electrical system requires significant improvements to efficiently and safely maintain existing Zoo operations and is inadequate for the proposed Zoo facilities. Required improvements include modifications to PG&E's high voltage system and replacement of major portions of the existing Zoo-owned low voltage system.

The future Zoo will have higher power requirements than the existing Zoo. This is primarily due to an increased number of facilities and more extensive heating, ventilation and water filtration/ recirculation requirements within the exhibits. The current power demand is estimated at 420 kW. The projected power demand for the future Zoo is estimated at 1,240 kW. Furthermore, the proposed location of new exhibits and facilities will require the relocation of portions of the existing electrical system.

The public telephone system and the Zoo's internal communication system will also require major improvements to improve current communications and meet future needs. The Zoo is currently preparing a plan for future Zoo communications. For coordination purposes, the conduit for the future communications system is included in this Infrastructure Master Plan.

Recommended Facilities and Improvements

The following electrical and communication facilities and improvements are recommended to serve the needs of the future Zoo and to correct several existing problems. The locations of the proposed facilities and improvements are shown on Figure 3-4.

Duct Bank

A new duct bank will be provided within the same utility corridor as the proposed water lines. The duct bank will contain a number of conduits for high voltage, low voltage, and future telephone and communications lines.

Transformers

Nine load areas have been developed for the Zoo Master Plan, each of which will be served from one transformer. A few of the existing transformers will be retained, such as for the Primate Discovery Center; other areas will require new transformers.

Switchboards

Two of the existing switchboards are corroded and/or filled to capacity, requiring replacement to meet existing and future needs.

Metering

The Zoo currently has seventeen watt-hour meters. The Zoo is charged at PG&E rates at three of these meters and at Hetch Hetchy rates at the others. To simplify the metering system, it is recommended that the PG&E rate meters be eliminated and that the metering system be simplified so that there is only one meter per supply transformer, charged at Hetch Hetchy rates.

Communications Conduit

Conduits will be provided within the duct bank described above for the future Zoo communication system.

Natural Gas System

Background

The Zoo's existing natural gas distribution system is corroded and inadequate to meet the natural gas needs of the existing Zoo and the future Zoo. Numerous gas leaks were identified following the 1989 earthquake and many additional leaks have been detected since then.

Natural gas demands for the future Zoo are anticipated to be about 10 percent higher than existing demands due to the increased heating requirements for the proposed exhibits and facilities.

Recommended Facilities and Improvements

The following natural gas facilities and improvements are recommended to serve the natural gas needs of the existing and future Zoo. The locations of the proposed facilities are shown on Figures 4-2 and 4-3.

Natural Gas Lines

Natural gas lines are typically (and recommended to be) installed, owned and operated by PG&E. The natural gas lines will be installed within the utility corridors. Most of the existing gas lines will be abandoned. Discussions with PG&E are continuing regarding the issue of installing the new gas lines concurrently with the other utilities when in fact most of the gas services will not be required for some time.

Gas Meters

As the projected gas loads are spread throughout the Zoo, several meters are recommended (see Figure 4-3). This is desirable because the Zoo will then only be responsible for maintaining the piping downstream of each meter. PG&E will be responsible for all piping upstream of each meter.

PROPOSED IMPLEMENTATION PLAN AND SCHEDULE

One of the objectives of this Infrastructure Master Plan is to plan the required utility improvements so that they can be constructed within the next three to four years without causing major disruptions to existing Zoo exhibits and facilities, yet still be flexible enough to efficiently serve future Zoo exhibits and facilities. In order to accomplish this, the various system improvements must be carefully sequenced and coordinated.

A proposed implementation schedule for the Zoo utility improvements is presented on Figure ES-1. This schedule shows the design, review, bidding and construction periods for each of the proposed utility improvements. The schedule also shows the design, review, bidding and construction schedules for the Zoo's proposed Mammal and Avian Conservation Centers which are an integral part of the Zoo Master Plan. These proposed conservation centers will provide necessary relocation facilities for sensitive animals while infrastructure system construction activities are occurring within the Zoo. As shown on the proposed schedule, no other construction activities associated with the infrastructure project are scheduled to begin until the construction of the Mammal and Avian Conservation Centers is complete and animals can be relocated.

Once the Mammal and Avian Conservation Centers are completed, construction activities related to the infrastructure improvements within the Zoo can begin. The first phase of construction will include the following facilities:

- New replacement wells;
- New groundwater reservoir;
- New groundwater booster pump station; and
- Wet weather lift station and discharge line to Westside Transport.

These facilities will be located in the northwestern portion of the Zoo, near the existing Children's Zoo. Construction of these facilities can be done concurrently; however, Zoo operations within that portion of the Zoo must be allowed to continue during the construction period.

Once the wet weather lift station and discharge line to the Westside Transport are completed, the construction of the new sewer collection system can be started "from the bottom up" as described in the Sewer/Drainage System section. With the corridor concept, the other utilities (water, electrical, communications conduit and natural gas) will be installed along with the sewer lines.

The utility replacement work will consist of the construction of utility corridors throughout the Zoo which contain all water (potable, groundwater and reclaimed water), sewer/drainage, electrical, communications conduit, and natural gas utilities. Construction

work will be limited to one or two areas of the Zoo at any given time to minimize disruption to Zoo operations and maintain open access corridors for Zoo operations.

A preliminary phasing plan for the utility replacement is provided on Figure ES-2. This figure shows the proposed construction segments in which construction can occur. Also shown on Figure ES-2 are the limitations for each construction segment including which animals may be impacted and the "prohibited" segments which should not be constructed concurrently in order to minimize disruptions to Zoo operations. A detailed construction phasing schedule considering animal sensitivities, Zoo operations and activities and environmental issues will be developed during the utility corridor design phase.

ENVIRONMENTAL REVIEW

A Negative Declaration has been prepared and approved by the City Office of Environmental Review (OER) for the improvements recommended in this Infrastructure Master Plan. The mitigation measures and monitoring requirements contained in the Negative Declaration have been considered in the development of this Infrastructure Master Plan and will be incorporated into the construction specifications for the utility corridor construction. A copy of the approved Negative Declaration is provided in Appendix A.

PROBABLE CONSTRUCTION COSTS

A summary of the probable construction costs for the proposed utility improvements is shown on Table ES-2.

TABLE ES-2

**PROBABLE CONSTRUCTION COST
SAN FRANCISCO ZOO INFRASTRUCTURE IMPROVEMENTS**

Infrastructure System	Estimated Direct Cost	Total Probable Construction Cost
Water Systems		
Potable Water Facilities	\$592,700	\$918,800
Groundwater Facilities	\$1,893,100	\$2,934,200
Reclaimed Water Facilities	\$388,700	\$602,500
Water Systems Subtotal	\$2,874,500	\$4,455,500
Sewer/Drainage System		
Collection System ¹	\$3,951,800	\$6,125,200
Drainage Improvements	\$40,800	\$63,200
Wet Weather Lift Station	\$1,397,700	\$2,166,400
Sewer/Drainage System Subtotal	\$5,390,300	\$8,354,800
Electrical/Communication Conduit Systems		
Electrical Distribution System	\$457,100	\$708,500
Communications Conduit	\$323,900	\$502,000
Electrical/Communication Conduit Systems Subtotal	\$781,000	\$1,210,500
Natural Gas System		
Gas Distribution System	\$211,400	\$327,700
Natural Gas System Subtotal	\$211,400	\$327,700
Construction Total	\$9,257,200	\$14,348,500
Design Costs	8 percent of construction total	\$1,147,900
Construction Management, Designer Services during Construction, Environmental Mitigation	13 percent of construction total	\$1,865,300
Total Costs		\$17,361,700

¹ Total probable construction cost for the sewer/drainage collection system includes \$284,300 for the conveyance of non-Zoo sanitary and storm flows through the Zoo system (including Harding Park Golf Course, Recreation Center for the Handicapped and State National Guard Armory).

More detailed tables showing the costs for proposed improvements for each utility system are provided in each section of this Infrastructure Master Plan. The direct costs have been estimated based on recent bids on similar projects and from standard cost estimating guides. The estimated direct costs have been adjusted using the following percentages to determine the total probable construction cost:

- Miscellaneous items: 10 percent
- Inflation adjustment: 4 percent

- Sales tax: 8.5 percent
- Subcontractor profit and administration: 15 percent
- Contractor profit: 10 percent
- Contingency: 10 percent

The percentage increase for miscellaneous items has been included to account for design details for each utility system which have not been accounted for at this preliminary planning stage of the infrastructure project. As the design progresses, the percentage included for this item will decrease.

Figure ES-1
Overall Implementation Plan

Legend: Red = Design, Teal = Review

**SAN FRANCISCO ZOOLOGICAL GARDENS
INFRASTRUCTURE MASTER PLAN
PROPOSED IMPLEMENTATION SCHEDULE**

Figure ES-1
Overall Implementation Plan

Legend: Red = Design, Teal = Review and Approval, Green = Bidding and Award, Blue = Construction

CONSTRUCTION SEGMENT LIMITATIONS

Prohibited Segment ¹	Potential Animal Impacts ²
NA	NA
NA	Children's Zoo
4, 21	Children's Zoo
3, 5, 9, 19, 21	Children's Zoo
4, 6, 9	Lake Birds, Marsupials, Kangaroos
5, 7, 9, 10	Lake Birds, Marsupials, Wild Dogs
6, 8, 10, 11	Sea Lions, Bears
7, 11	Bears, Llama, Rhino
4, 5, 6, 10	Koala, Lake Birds
6, 7, 9, 13	Water Buffalo
7, 8, 12	Rhino, Llama, Blackbuck
11, 13, 14, 15	Rhino, Nyala, Ostrich
10, 12, 14, 18	Penguin, Elephant, Otter
12, 13, 15	Lion House
12, 14	Elephant, Hippo
17	Elephant, Zebra, Feline Conservation Ctr
16, 18	Giraffe, Zebra, Feline Conservation Ctr
13, 17, 19	Primates, Chimp, Orangs
4, 18, 20	Siamang, Flamingo
19	Children's Zoo
3, 4	Children's Zoo
NA	Musk Ox, Gorillas
NA	Giraffe, Gorillas
NA	NA
NA	Feline Conservation Center
NA	Avian Conservation Center

aneous work prohibited because of Zoo operations requirements.
 neous work may be prohibited in additional segments due to animal
 ity requirements or utility operation constraints.
 are based on current animal locations.
 licable

LEGEND

- Proposed Sewer Mains
- Proposed Utility Corridors
- Proposed Construction Segment

Kennedy/Jenks Consultants-AGS Inc. An Association

San Francisco Zoological Gardens
 Zoo Infrastructure Master Plan

Schematic Layout of Future Utility Corridors and Construction Segments Within The Existing Zoo

K/J 930524 / ASG 920801
 August 1995

Figure ES-2

CONSTRUCTION SEGMENT LIMITATIONS

Segment No.	Prohibited Segment ¹	Potential Animal Impacts ²
1	NA	NA
2	NA	Children's Zoo
3	4, 21	Children's Zoo
4	3, 5, 9, 19, 21	Children's Zoo
5	4, 6, 9	Lake Birds, Marsupials, Kangaroos
6	5, 7, 9, 10	Lake Birds, Marsupials, Wild Dogs
7	6, 8, 10, 11	Sea Lions, Bears
8	7, 11	Bears, Llama, Rhino
9	4, 5, 6, 10	Koala, Lake Birds
10	6, 7, 9, 13	Water Buffalo
11	7, 8, 12	Rhino, Llama, Blackbuck
12	11, 13, 14, 15	Rhino, Nyala, Ostrich
13	10, 12, 14, 18	Penguin, Elephant, Otter
14	12, 13, 15	Lion House
15	12, 14	Elephant, Hippo
16	17	Elephant, Zebra, Feline Conservation Ctr
17	16, 18	Giraffe, Zebra, Feline Conservation Ctr
18	13, 17, 19	Primates, Chimp, Orangs
19	4, 18, 20	Siamang, Flamingo
20	19	Children's Zoo
21	3, 4	Children's Zoo
22	NA	Musk Ox, Gorillas
23	NA	Giraffe, Gorillas
24	NA	NA
25	NA	Feline Conservation Center
26	NA	Avian Conservation Center

¹ Simultaneous work prohibited because of Zoo operations requirements. Simultaneous work may be prohibited in additional segments due to animal sensitivity requirements or utility operation constraints.
² Impacts are based on current animal locations.
NA Not Applicable

LEGEND

- Proposed Sewer Mains
- Proposed Utility Corridors
- Proposed Construction Segment

Kennedy/Jenks Consultants-AGS Inc. An Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Schematic Layout of Future Utility Corridors and Construction Segments Within The Existing Zoo

K/J 930524 / ASG 920801
August 1995

Figure ES-2

POTABLE, GROUNDWATER AND RECLAIMED WATER SYSTEMS

INTRODUCTION

The Zoo is currently served by two water supply systems -- potable water supply from the San Francisco Water Department (SFWD) system and groundwater supply from a City of San Francisco owned and operated groundwater well system within the Zoo for irrigation and washdown in the western portion of the Zoo. The current potable water distribution system and groundwater supply and distribution systems are old, were physically damaged in the 1989 earthquake and are unable to reliably serve the Zoo's water supply needs. Replacement of these systems is required to reliably serve the current and future Zoo facilities. In addition to the potable water and groundwater supplies, the Zoo may also have future access to reclaimed water for irrigation uses.

This section of the Zoo's Infrastructure Master Plan contains the background, design criteria, design assumptions and the recommended improvements for the future potable, groundwater and reclaimed water systems for the San Francisco Zoo.

The planning concepts for the future water supply systems are based on assumed uses of each of the water supply sources available to the Zoo. The assumed uses are shown in Table 1-1.

**TABLE 1-1
ASSUMED WATER USES**

Future Water Supply System	Water Uses
Potable Water	Human related uses (drinking, cafes, restrooms, etc.), animal drinkers, and to supply fire demands at hydrants and building sprinkler systems.
Groundwater	Pool filling, washdown of animal areas, irrigation within exhibits, ornamental streams and filter backwashing of exhibit pools.
Reclaimed Water	When available, will be used for general irrigation purposes.

Since reclaimed water is not currently available at the Zoo, groundwater will be used in the interim for general irrigation uses, in addition to the demands mentioned above.

WATER DEMANDS

Existing Demands

There are many existing water uses at the Zoo, including:

- Potable uses, such as for cafes, drinking fountains, public restrooms, the hospital, and administrative staff uses;
- Washdown at exhibits;
- Pool filling at the animal exhibit area;
- Makeup water for leakage and overflow;
- Irrigation water; and
- Fire flows.

Currently, potable water is supplied for all of these uses, although groundwater is supplied for some irrigation and washdown uses on the west side of the Zoo. The existing average day demands, as shown in Table 1-2, were estimated based on meter records for potable uses and well pump rates for groundwater uses.

**TABLE 1-2
EXISTING WATER DEMAND**

Water Supply	Estimated Average Day Use (gallons per day, gpd)
Potable Water	450,000
Groundwater	216,000
Total	666,000

Future Demands

Future water demands were based on the number and types of new exhibits, the estimated maximum number of visitors on "Free Day," and the overall future landscaping plan as presented in the Zoo Master Plan (Portico, 1994). Estimates of future water demands at buildout of the Zoo Master Plan are presented in Table 1-3.

TABLE 1-3
ESTIMATED DEMANDS FOR FUTURE POTABLE, GROUNDWATER
AND RECLAIMED WATER SYSTEMS

Use	Typical Operating Day Demand			Maximum Day Demand		
	Basis of Design	gpd	gpm	Basis of Design	gpd	gpm
Potable						
Restrooms	5 gpd per visitorx10,000 visitors + 10 gpmx8hrs for staff	54,800	129 ⁽¹⁾	5 gpd per visitorx30,000 visitors + 10 gpmx8hrs for staff	154,800	367 ⁽¹⁾
Cafes	10,000 visitors, 1 gal per visitor	10,000	24 ⁽¹⁾	30,000 visitors, 1 gal per visitor	30,000	71 ⁽¹⁾
Other	7 gpmx8 hrs for drinking fountains, animal care at hospital, general cleaning at other facilities (40 gpm peak flow rate)	3,360	40 ⁽⁹⁾	Same as typical day	3,360	40 ⁽⁹⁾
Groundwater						
Washdown	Assume 280 gpm peak flow (3 1-in hoses @ 20 gpm + 22 3/4-in hoses @ 10 gpm) Assume washdowns occur 4 hrs per day	67,200	280 ⁽⁹⁾	Same as typical day	67,200	280 ⁽⁹⁾
Pool Filling/ Filter Backwash	Filter backwash of all pools based on the future pool volume (1.52 mg)	118,750 ⁽²⁾	1200 ⁽³⁾	Largest (800 gpm) and 2nd largest (400 gpm) pools refill. Backwash of all other pools (1.1 mg)	501,328 ⁽²⁾	1200 ⁽³⁾
Leakage/Overflow	Exhibit pool overflow and leakage	50,000	35	Same as typical day	50,000	35
Reclaimed						
Irrigation	Typical = 0.5 x Max Day demand	118,000	1,500 ⁽⁴⁾	1.5 in per week (6 hrs per day, 7 days per week) ⁽⁶⁾	236,000	1,500 ⁽⁴⁾
Totals						
Potable ⁽⁵⁾		68,160	193		188,160	478
Groundwater ⁽⁶⁾		235,950	1,515 ⁽³⁾		618,528	1,515 ⁽³⁾
Reclaimed ⁽⁷⁾		118,000	1,500		236,000	1,500
TOTALS		422,110	3,208		1,042,688	3,493

⁽¹⁾ Assume visitor day is equal to 7 hours.

⁽²⁾ Typical day: all pools backwash. Total pool volume is filtered in 24 hours, 2 gpm/sf filtration, 15 gpm/sf backwash, 15 min duration. Maximum day: two largest pools refill (total volume is 415,000 gal); others backwash at same rate as typical day.

⁽³⁾ Largest (800 gpm) plus the second largest (400 gpm) pool refill after filter backwashing. Pool refill rate is assumed to be 1,200 gpm on typical and maximum day.

⁽⁴⁾ Maximum daily application rate based on assumed irrigation zone boundaries (see Figure 1-6). Irrigation rate is assumed to be 1,500 gpm on typical and maximum day.

⁽⁵⁾ Potable demand includes restrooms, cafes and other uses.

⁽⁶⁾ Groundwater demand includes pool filling, filter backwashing and leakage and overflow.

⁽⁷⁾ Reclaimed water demand includes landscaped irrigation.

⁽⁸⁾ Landscaped areas (40.5 acres) based on Zoo Master Plan (Portico, 1994).

⁽⁹⁾ Water uses required for daily Zoo operations; assumed to be the same every day.

DESIGN PHILOSOPHY

The Zoo's three water supplies, although each has distinct uses, will provide the Zoo with a high level of water supply reliability and redundancy. Each supply source will be capable of providing backup supplies in the event of an interruption to a supply source. Examples of this redundancy are provided below:

- Because the Zoo's potable water system is, and will continue to be, an extension of the City's potable water supply system, it will only be as reliable as the City's overall system. If the City's system is interrupted or fails, potable water service to the Zoo will be interrupted. In the event that this occurs, the Zoo's groundwater system (wells, reservoir and booster pump station) would be capable of serving the Zoo's immediate water needs (e.g. animal drinking and pools).
- In the event that the Zoo's wells are out of service for a period of time, the potable water supply can be utilized to meet the demands of the groundwater system. This will be made possible via an air-gapped connection of the potable system to the Zoo's groundwater reservoir. Also, the Zoo's groundwater reservoir will provide storage for the Zoo's short-term needs.
- Initially, until reclaimed water becomes available, groundwater will be used to meet all irrigation demands at the Zoo. However, even after the reclaimed water is available, there may be instances when the reclaimed water supply is not available. To allow for continued irrigation of the Zoo's landscaping, the reclaimed water supply will be backed up using the groundwater supply via a connection with a reduced pressure backflow preventer between the two systems.

DESIGN CRITERIA

This section describes the design criteria which were used in the analysis of the Zoo's proposed future potable, groundwater and reclaimed water distribution systems. These design criteria were used to evaluate and size the future Zoo's water distribution pipelines and other water supply facilities.

Potable Water System

1. The minimum allowable system pressure is 20 psi during a maximum day plus fire flow demand. These are typical minimum pressures for municipal water supply systems.
2. Pipe velocities will not exceed 10 feet per second (fps) during maximum day flows.
3. Pipeline headlosses during average day demand should not exceed 3 feet per 1,000 feet of pipeline.

4. The fire flow requirement for existing and new buildings and exhibits is 2,500 gpm. This requirement is based on building size and type of construction and assumes that the buildings are not sprinklered.
5. The minimum number of hydrants used to supply the fire flow of 2,500 gpm is three with an average spacing between hydrants equal to approximately 450 feet (1991 UFC Table No. A-III-BB-1).
6. The average spacing between hydrants at the Zoo will be approximately 300 feet.
7. Fire hydrants shall be supplied from water mains that are at least 6 inches in diameter. When dead-end pipeline runs exceed 300 feet, the pipelines will be a minimum of 8-inches in diameter. When dead-end pipeline runs exceed 600 feet, the pipelines are to be a minimum of 10 inches in diameter (NFPA Standard 1141, 1990).
8. Isolation valves shall be installed at all tees and crosses, and no more than 800 feet apart (AWWA Recommendation).

Groundwater System

1. The minimum allowable system pressure is 90 psi during peak hour demands. This minimum pressure is based on the pressure needed for washdown of exhibits.
2. The peak hour demand is defined as all washdown demands occurring simultaneously with the two largest pools refilling after backwash.
3. Pipe velocities will not exceed 10 fps during maximum day demands.
4. Isolation valves shall be installed at all tees and crosses, and no more than 800 feet apart (AWWA Recommendation).
5. Irrigation demands, to be met by groundwater until reclaimed water becomes available, are assumed to be off-peak demands, not occurring simultaneously with other groundwater demands.

Reclaimed Water System

1. The minimum allowable system pressure is 60 psi during peak hour demands. This minimum pressure is based on the pressure requirement for irrigation sprinkler systems. Anticipated incoming pressure is anticipated to be 130 psi.
2. The peak hour demand is defined as the landscape irrigation demand applied to a specific area for a total of 1.5 inches per week based on a one hour per day irrigation period, 7 days a week.

3. Pipe velocities will not exceed 10 fps during maximum day flows.
4. Isolation valves shall be installed at all tees and crosses, and no more than 800 feet apart (AWWA Recommendation).

The proposed water system improvements for the Zoo will meet or exceed the above criteria.

DESIGN CONSTRAINTS/ASSUMPTIONS

The following sections describe the design constraints and assumptions for the water systems based on meetings with City and Zoo Staff.

Fire Flows

Fire hydrants and building sprinklers will be installed on the potable water system pipelines within the Zoo and a combination service (for domestic and fire service) will be provided for the Zoo.

Interties between Systems

In general, interties between potable and non-potable sources are not allowed; however, interties can be desirable to provide backup supplies. The Zoo is limited in the amount of space it can provide for groundwater storage facilities and groundwater yields are limited. Therefore, potable water will provide a backup water supply to the groundwater system via an air-gapped connection into the groundwater reservoir.

The reclaimed water system (for irrigation) will be backed up using the groundwater supply. A reduced pressure backflow preventer will be provided between the two systems.

EVALUATION OF THE FUTURE DISTRIBUTION SYSTEMS

This section presents the evaluation of the Zoo's proposed future potable, groundwater and reclaimed water distribution systems and their ability to meet demands at ultimate buildout of the Zoo Master Plan. The evaluation is based on the criteria presented in previous sections and discussions with City and Zoo Staff.

Overall Model Development

Several alternatives for each of the water systems were evaluated. The recommended system is a network of interior looped utility corridors. All three water systems will be installed in these utility corridors, with most of the existing piping being replaced.

A schematic of the future system configuration was developed based on the Zoo Master Plan. This layout was compared to the existing Zoo layout and the alignments were adjusted to minimize disruption to existing exhibits and buildings.

A schematic diagram of the utility corridors proposed for the three water distribution systems in the future Zoo is shown on Figure 1-1. The relationship of these utility corridors to the existing Zoo exhibit layout is presented on Figure 1-2.

Methodology

Computer models were created to evaluate the potable, groundwater and reclaimed water distribution systems. Each of these distribution systems was evaluated under the following demand scenarios with the appropriate demands as presented in Table 1-3:

- Potable Water System: Maximum day plus fire flow demands
- Groundwater System: All washdown demands occurring simultaneously while the two largest exhibit pools are filling
- Reclaimed Water System: Peak hour irrigation demands

A summary of the demand scenarios is provided in Table 1-4.

**TABLE 1-4
WATER SYSTEM DEMAND SCENARIOS**

System Design Criteria	Potable Water System		Groundwater System		Reclaimed Water System	
	Maximum Flow (gpm)	Minimum Pressure (psi)	Maximum Flow (gpm)	Minimum Pressure (psi)	Maximum Flow (gpm)	Minimum Pressure (psi)
Maximum Day Domestic Plus Fire Flow ⁽¹⁾	2,978	20	-	-	-	-
Peak Hour Washdown Demand	-	-	1,515	90	-	-
Peak Hour Irrigation Demand	-	-	-	-	1,500	60

⁽¹⁾ Fire flow demand is 2,500 gpm.

The above conditions were simulated to adequately size each of the proposed future water distribution networks and facilities. As discussed previously, until reclaimed water is available, groundwater will be used to meet irrigation demands. For planning purposes, it

has been assumed that the irrigation demand on the groundwater system will be an off-peak demand, not occurring simultaneously with the other groundwater demands (washdown and pool filling).

Each of the scenarios and the conditions under which they were evaluated is described below.

Potable Water System

For the potable water scenario, a maximum day potable water demand of 478 gpm and a fire flow demand of 2,500 gpm were assumed to take place simultaneously. The model was used to simulate a fire demand in the southwest corner of the future Zoo. This location was chosen because it is the farthest point from the existing meter connections, and it is near the existing (and future) administration buildings where the largest fire demand would most likely occur. The model was run with the following assumptions:

- The proposed system configuration consisted of 6-inch-diameter loops throughout the utility corridors and the use of the existing 6-inch meter connections to the City's potable water system;
- The 2,500 gpm fire flow was divided among three hydrants (800, 900 and 800 gpm), an average of 300 feet apart; and
- Constant pressure nodes were entered at each of the meter connections and were set to equal the static pressures that were observed during the hydrant tests of the existing SFWD distribution system on 30 August 1994.

During this scenario, the assumed system configuration was unable to maintain the minimum design pressures (see Figure 1-3). Simulated pressures dropped to as low as 6 psi, and velocities were in excess of 18 fps. Both of these results indicate that the assumed system configuration is insufficient to meet the minimum design criteria.

There are two reasons why the assumed system was unable to meet minimum design criteria. The first was that the existing meters and reduced pressure backflow preventers (RPBP) are unable to handle large flows. This is indicated by the large velocities and headlosses through the meters. The second reason is that there are some very long pipeline runs within the assumed system; however, an internal loop to help alleviate some of these long pipeline runs would be costly and would disrupt many of the most sensitive animals in the Zoo, including the chimpanzees and gorillas.

In order to reduce the large velocities and headlosses through the meters and RPBPs, the following system improvements were assumed:

- The meter connections to the City's potable water system were assumed to be upgraded from 6-inch to 8-inch. This includes the service laterals, the meters and the RPBPs; and

- An additional supply point along Herbst Road was assumed.

The additional supply point was assumed from the proposed new service line which will also be needed to provide potable water to the proposed Avian and Mammal Conservation Centers. This pipeline was assumed to provide the same static pressures as the other meter connections. Adding this 10-inch-diameter service will not only help to increase system pressures, but will also provide additional reliability and redundancy to the Zoo's supply system.

With both of these modifications made to the proposed configuration, the proposed system met all design criteria. In fact, the simulated pressures within the Zoo did not fall below 55 psi and the velocities did not exceed 9 fps. Figure 1-4 presents the simulated pressures and the new proposed configuration. In reality, the pressures throughout the Zoo will probably be below the indicated 55 psi residual but will remain above 20 psi during a fire. This is because static pressures were used at the meter connections in the model during the fire flow simulation. Additional hydrant flow tests, which include hydrants within the Zoo, would be required to further refine this analysis.

Groundwater System

For this scenario, it was assumed that all of the washdown demands (approximately 280 gpm) would be occurring simultaneously while the two largest exhibit pools were filling. The largest exhibit pool in the future Zoo is the elephant pool which holds approximately 275,000 gallons, and was assumed to fill at a rate of 800 gpm. There are a few other exhibit pools which qualify as the second largest, but the second largest exhibit pool that is closest to the elephant pool, is in the Gibbon exhibit. This exhibit pool holds approximately 140,000 gallons, and was assumed to fill at a rate of 400 gpm.

To meet the minimum design criteria of 10 fps maximum velocity and minimum pressures of 90 psi, the groundwater pumping station located in the northwest corner of the Zoo was sized to pump 1,500 gpm at a discharge pressure of 130 psi (300 feet of head). With the design pressure and flow set, the proposed groundwater system was able to meet all minimum design criteria with a looped configuration of 6-inch-diameter pipelines and a small length of 8-inch-diameter pipeline coming from the pump station. Figure 1-5 presents the proposed system configuration and simulated pressures from this scenario.

Reclaimed Water System

For this scenario, it was assumed that peak hour irrigation demands would not occur simultaneously throughout the Zoo, but that irrigation zones with phased operation schedules would be established. Six irrigation zones were assumed in the reclaimed water system configuration (see Figure 1-6). These zones correspond approximately with the exhibit complexes as presented in the Exhibit Complexes figure in the Zoo Master Plan (Portico, 1994). Each irrigation zone was modeled to see if, at any point, the system pressures fell below the minimum design criteria pressure of 60 psi.

Since reclaimed water is currently unavailable, in addition to pool filling and washdown demands, the groundwater system via its pump station will meet the irrigation demands

initially. It has been assumed that the irrigation demand will be an off-peak demand, not occurring simultaneously with other groundwater demands (washdown and pool filling). Groundwater will be provided for irrigation from the booster pump station at a discharge pressure of 130 psi; this will result in operating pressures within each zone of the irrigation system which exceed the minimum design criteria pressure of 60 psi.

When reclaimed water becomes available, the incoming pressure may be lower than that of the groundwater system. If the incoming pressure is 95 psi or higher, the minimum design criteria pressure of 60 psi can be maintained using a 6-inch-diameter looped distribution system, as shown on Figure 1-7. If the incoming pressure is lower than 95 psi, to a minimum incoming pressure of 75 psi, the minimum design criteria pressure of 60 psi can be maintained using an 8-inch-diameter looped distribution system.

DESCRIPTION OF PROPOSED FACILITIES

This section describes the facilities recommended for the proposed potable, groundwater and reclaimed water distribution systems. Figures 1-8 and 1-9, respectively, present a schematic of these facilities located within the future and existing Zoo.

Distribution Pipelines

Each of the three distribution systems requires minimum 6-inch-diameter pipelines, with some additional 8-inch-diameter pipelines from each of their supply points. Because of the relatively shallow cover depths, direct burial will be the preferred installation method for the water system pipelines.

As a precaution against future unwanted cross-connections, and since these three pipelines will be roughly all the same size and in the same utility corridor, it is recommended that a method be established to distinguish these pipelines from one another. Table 1-5 presents the recommended type and color "standard" and expected design life for each of the required systems.

**TABLE 1-5
RECOMMENDED WATER SYSTEM MATERIALS**

Water Supply	Material ⁽¹⁾	Color	Expected Life
Potable Water	Ductile iron	--	75 years
Groundwater	Polyvinyl chloride (PVC) C900	White	75 years
Reclaimed Water	Polyvinyl chloride (PVC) C900	Purple	75 years

⁽¹⁾ Pipe material, class and type will be verified during the design phase based on pipe installation and pressure conditions.

With these type and color "standards," accidental cross-connections will be avoidable. These "standards" will also assist in future locating of each of the systems.

Potable Supply Connections

In order to increase the reliability and redundancy of the potable water system, it is recommended that the three existing 6-inch supply connections to the City system be increased to 8-inch connections and that a new 10-inch supply point be established along Herbst Road. For the existing connections, this will involve the upsizing of the existing meters, RPBP's and service lines from 6-inch to 8-inch. The new supply point will consist of a 10-inch meter, RPBP and service line. This new supply connection will also be the primary potable water supply point for the new Avian and Mammal Conservation Centers.

Groundwater Wells

Two new replacement wells will be installed to replace the City's current Zoo wells #3 and #4, which are in poor condition. Each well will be constructed with a 16-inch-diameter well casing to a depth of approximately 520 feet. Based on the production capacity of the Zoo's two existing wells, each new well is anticipated to yield approximately 1,250 gpm; however, only one well will be pumped at a time, while the other well will serve as a standby well. Each well will have a small pump house and buried discharge line which will discharge to the Zoo's groundwater reservoir (see description of reservoir below). The locations of the new Zoo wells (#5 and #6) are shown on Figures 1-8 and 1-9. Existing Zoo wells #3 and #4 will be destroyed in accordance with State and local requirements following completion of the new replacement wells. A complete report on the construction of the new wells and the destruction of the existing wells is contained in Appendix B.

Groundwater Booster Pump Station

As was previously described, a new groundwater booster pump station capable of providing 1,500 gpm, at approximately 300 feet of head, is required to meet the needs of the groundwater system. This new booster pump station will also be required to separately meet the existing irrigation needs along Great Highway.

The new booster pump station will serve the washdown and pool filling/backwashing demands during the day while in the evening it will provide the water for irrigation. The booster pump station will contain variable speed pumps or pumps installed in parallel to provide constant head and variable flow conditions to accommodate varying daily demand conditions.

The existing reservoir and booster pump station will be utilized until a new reservoir and booster pump station are constructed.

Groundwater Reservoir

Storage facilities for the groundwater system at the Zoo have been sized so that the Zoo's maximum future demand for groundwater, exclusive of irrigation, can still be met in the event that both well pumps are inoperable for up to a one-day period. From the data in Table 1-3, the maximum total daily groundwater use can be calculated as shown in Table 1-6.

**TABLE 1-6
GROUNDWATER RESERVOIR VOLUME**

Purpose	Groundwater Use (gallons per day)
Washdown Volumes	67,200
Pool filling (largest pool only)	275,000
Leakage and overflow	50,000
Total	392,200

Therefore, the one-day storage requirement for the Zoo needs is approximately 390,000 gallons. In addition to providing back up to the well pumps, this storage volume would also serve as operational storage to meet peak night-time irrigation demands.

The new groundwater reservoir will be an underground concrete reservoir located in the northwestern portion of the Zoo near the future Zoo parking lot. In the interim, the Zoo's current groundwater reservoir and booster pump station will be utilized.

COST ESTIMATES

Estimates of the total probable construction cost for the water system improvements are presented in Table 1-7.

TABLE 1-7
PROBABLE CONSTRUCTION COST
POTABLE, GROUNDWATER AND RECLAIMED WATER SYSTEMS

Water System Facility	Estimated Direct Cost	Total Probable Construction Cost
Potable Water Facilities		
Distribution pipelines	\$395,400	\$918,800
Upsize existing service connections	\$64,500	\$100,000
Provide new service connection	\$27,000	\$41,900
Appurtenances	\$105,800	\$164,000
Potable Water Subtotal	\$592,700	\$918,800
Groundwater Facilities		
Distribution pipelines	\$298,900	\$463,300
Appurtenances	\$79,900	\$123,800
Booster pump station	\$215,500	\$334,000
Groundwater reservoir	\$475,000	\$736,200
Replacement wells	\$823,800	\$1,276,900
Groundwater Subtotal	\$1,893,100	\$2,934,200
Reclaimed Water Facilities		
Distribution pipelines	\$332,200	\$918,800
Appurtenances	\$56,500	\$87,600
Reclaimed Water Subtotal	\$388,700	\$602,500
Totals	\$2,874,500	\$4,455,500

The estimated direct costs have been marked up with the following percentages:

- Miscellaneous items: 10 percent
- Inflation adjustment: 4 percent
- Sales tax: 8.5 percent
- Subcontractor profit and administration: 15 percent
- Contractor profit: 10 percent
- Contingency: 10 percent

The direct costs have been estimated based on recent bids on similar water facility projects and from standard cost estimating guides.

Costs for construction management, designer services during construction and environmental mitigation are not shown in Table 1-7 (see Table ES-2 in the Executive Summary).

IMPLEMENTATION

This section addresses the implementation and staging of the future distribution systems in coordination with the existing water facilities. Since the exact phasing of the exhibits is

unknown at this time, the general sequence of water system improvements is described as follows:

- Construct new City potable water service connection to provide service for Avian and Mammal Conservation Centers;
- Replace existing Zoo groundwater wells and destroy existing wells;
- Construct new groundwater reservoir and booster pump station;
- Modify existing City potable water service connections from the SFWD distribution system (without disturbance to the existing Zoo);
- Install new pipelines without destruction of existing exhibits;
- Connect existing service lines to new mains;
- As new exhibits are constructed, install new service lines to new mains; and
- Reclaimed water may, in the future, replace groundwater for some irrigation uses.

The implementation of the water distribution piping should, wherever possible, coincide with the implementation of the other utility systems. Therefore, if a sewer line (or other utility system) must be installed immediately to correct an existing problem, then the three new water lines should also be installed in that area at the same time. This method of implementation will allow minimal disruption to the existing Zoo, and will prevent trenching and backfilling operations from being repeated for separate utility systems throughout the Zoo at different times.

LEGEND

Proposed Utility Corridors

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Schematic Layout of Future Utility Corridors Within The Future Zoo

K/J 930524 / AGS 920801
August 1995

Figure 1-1

LEGEND

Proposed Utility Corridors

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Zoo Infrastructure Master Plan

**Schematic Layout of Future Utility Corridors
within the Existing Zoo**

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Figure 1-2

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Zoo Infrastructure Master Plan

Schematic Layout of Future Utility Corridors
within the Existing Zoo

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Figure 1-2

NOTE:

Color:

All pipelines are 6-inch diameter.

Section

Pressure

Hydrant)

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**Simulated Pressures For
Potable Water System**

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Figure 1-3

LEGEND:

Pressure Ranges (psi) by Color:

0	20
20	30
30	40
40	50
50	65

- Proposed Pipelines
- 6-inch Meter Connection
- 6-inch Reduced Pressure Backflow Preventer
- ⊙ Fire Hydrant (Resulting Pressure at Fire Hydrant)

NOTE:

All pipelines are 6-inch diameter.

Simulated Fire Demand of 2500 GPM

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**Simulated Pressures For
Potable Water System**

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Figure 1-3

NOTE:

All pipelines are 6-inch diameter unless otherwise noted.

Color:

ing
drant)

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**Simulated Pressures For
Modified Potable Water System**

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Figure 1-4

LEGEND:

Pressure Ranges (psi) by Color:

0	20
20	30
30	40
40	50
50	65

- Proposed Pipelines
- Meter Connection
- Reduced Pressure Backflow Preventer
- Fire Hydrant (Resulting Pressure at Fire Hydrant)

NOTE:

All pipelines are 6-inch diameter unless otherwise noted.

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Zoo Infrastructure Master Plan

**Simulated Pressures For
Modified Potable Water System**

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Figure 1-4

Simulated Gibbon
Exhibit Pool Filling
409 gpm

NOTE:

All pipelines are 6-inch diameter
unless otherwise noted.

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Zoo Infrastructure Master Plan

**Simulated Pressures for
Groundwater System**

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Figure 1-5

Simulated Gibbon
Exhibit Pool Filling
409 gpm

- Simulated Elephant
Pool Filling
818 gpm

LEGEND

Pressures Ranges (psi) by Color:

0	90
90	100
100	110
110	120
120	130

Proposed Pipelines

NOTE:

All pipelines are 6-inch diameter unless otherwise noted.

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Simulated Pressures for Groundwater System

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August 1995

Figure 1-5

NOTES:

1. All pipelines are 6-inch diameter unless otherwise noted.
2. Assume minimum incoming pressure of 95 psi
3. Larger diameter pipelines would be required if incoming pressure is below 95 psi.
4. Initially served thru groundwater booster pump. Later served by tertiary plant.

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**Simulated Pressures For
Reclaimed Water System**

K/J 930524 / AGS 920801

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Figure 1-7

LEGEND

Pressure Ranges (psi) by Color:

0	60
60	65
65	70
70	75
75	100

— Proposed Pipelines

NOTES:

1. All pipelines are 6-inch diameter unless otherwise noted.
2. Assume minimum incoming pressure of 95 psi
3. Larger diameter pipelines would be required if incoming pressure is below 95 psi.
4. Initially served thru groundwater booster pump. Later served by tertiary plant.

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**Simulated Pressures For
 Reclaimed Water System**

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Figure 1-7

NOTE:

All pipelines are 6-inch diameter unless otherwise noted.

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**Schematic Layout of Future Water Facilities
Within The Future Zoo**

K/J 930524 / AGS 920801

August 1995

Figure 1-8

LEGEND

- Proposed Utility Corridors (Potable, Groundwater, Reclaimed)
- Proposed Service Connection to City Water
- New Meter
- New Reduced Pressure Backflow Preventer
- Replacement Wells
- Existing Groundwater Pump Station
- New Groundwater Pump Station

NOTE:

All pipelines are 6-inch diameter unless otherwise noted.

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 San Francisco Zoological Gardens
 Zoo Infrastructure Master Plan

**Schematic Layout of Future Water Facilities
 Within The Future Zoo**

K/J 930524 / AGS 920801
 August 1995

Figure 1-8

LEGEND

- **Proposed Utility Corridors (Potable, Groundwater, Reclaimed)**
- **Proposed Service Connection to City Water**
- **New Meter**
- **New Reduced Pressure Backflow Preventer**
- **Replacement Wells**
- **Existing Groundwater Pump Station**
- **New Groundwater Pump Station**

NOTE:

All pipelines are 6-inch diameter unless otherwise noted

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Schematic Layout of Future Water Facilities
Within the Existing Zoo

K/J 930524 / AGS 920801

August 1995

Figure 1-9

LEGEND

- Proposed Utility Corridors (Potable, Groundwater, Reclaimed)
- Proposed Service Connection to City Water
- New Meter
- New Reduced Pressure Backflow Preventer
- Replacement Wells
- Existing Groundwater Pump Station
- New Groundwater Pump Station

NOTE:

All pipelines are 6-inch diameter unless otherwise noted

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Schematic Layout of Future Water Facilities
Within the Existing Zoo

K/J 930524 / AGS 920801

August 1995

Figure 1-9

SEWER/DRAINAGE SYSTEM

INTRODUCTION

The Zoo's existing sewer/drainage system is deteriorated and inadequate to handle the Zoo's existing flows and projected future flows. Currently, the existing system backs up and causes localized flooding within the Zoo during high flow periods. During the winter storms in 1995, the Zoo actually had to remain closed for several days due to severe flooding near the Zoo's main entrance and the Mother's Building. Several areas of the Zoo are vulnerable to severe flooding during periods with high combined sewer and storm flows.

This section of the Zoo's Infrastructure Master Plan describes the preliminary design of the Zoo's future combined sewer system, including design objectives, design criteria, modeling assumptions, proposed layout, description of proposed facilities, preliminary cost estimates, and proposed implementation.

The combined system was developed and analyzed using the HYDRA sewer model to determine flow rates, sewer sizes, and velocities under average dry weather conditions and peak wet weather conditions. A 5-year design storm was used for the peak wet weather conditions in accordance with City standard design criteria.

The primary design objectives of the future combined sewer system are:

- Flow by gravity during dry weather.
- Eliminate flooding by storm events with less than a 5-year return frequency.
- Minimize impacts to the public and to Zoo animals.
- Minimize operational and construction costs.

These general objectives represent the basis of the preliminary backbone system design.

DESIGN FLOWS

The proposed system was modeled for average dry weather flow within the Zoo to assure minimum velocities, and peak wet weather flow from a 5-year return period storm to determine system capacity requirements. The proposed system was also designed to include flows from the Harding Park Golf Course, the Recreation Center for the Handicapped and the State National Guard Armory. These flows are currently conveyed through the Zoo via the Harding Park Sewer and other existing Zoo lines. The design flows were determined as described below.

Average Dry Weather Flow

The average dry weather design flow for the Zoo and the upstream areas described above was estimated to be approximately 2,200 gpm during the Zoo's typical 10-hour daily period of operation. Because of the unique characteristics of wastewater flows at the Zoo, standard calculations of average dry weather flow based on per capita flow or diurnal flow curves were not used. Table 2-1 summarizes the estimated wastewater flows for the Zoo, and how they were used to calculate average dry weather wastewater flows.

TABLE 2-1
WASTEWATER DESIGN FLOWS AT LIFT STATION

Source	Description	Average Dry Weather Design Flow	Peak Wet Weather (5-Year Storm) Design Flow
Domestic	Restrooms, cafés, drinking fountains, etc. (Daily)	1.1 cfs	1.1 cfs
Exhibit Washdown	Simultaneous washdown of exhibits daily using 1-inch hoses (Daily)	1.6 cfs	1.6 cfs
Filter Backwash	Two largest filters on each branch backwashed simultaneously (Daily)	-	10.4 cfs
Pool Drainage	Largest pool on each branch drained simultaneously (Monthly)	-	2.2 cfs
Infiltration	0.003 cfs/acre	0.3 cfs	0.3 cfs
5-Year Storm Flow	By rational method. Flows vary based on system configuration and time of concentration. Value shown for total flow entering the proposed wet weather pump station.	-	61.0 cfs
Non-Zoo Sources (Sanitary and Storm Flows)	Harding Park Golf Course, Recreation Center for the Handicapped and State National Guard Armory. Flows based on calculations by the City Department of Public Works	1.9 cfs	12.4 cfs
TOTAL		4.9 cfs (2,200 gpm)	89.0 cfs (40,000 gpm)

The average dry weather design flow was approximated as domestic flow plus exhibit washdowns and infiltration. To avoid the impact of higher, less frequent flows on the system design under average dry weather flow conditions, filter

backwash and pool drainage flows were not included. This has resulted in a more conservative approach to the average dry weather flow design of the new sewer system.

Peak Wet Weather Flow

The peak wet weather flow (5-year storm flow) was determined using time/intensity and hyetograph information provided by the City. This information was previously presented in Technical Memorandum No. 1 (K/J-AGS, 1993). Runoff was calculated using the Rational Method, which considers storm intensity, time of concentration and the percentage of rainfall which becomes runoff (C factor).

The future Zoo was divided into approximately 30 drainage basins, and C factors were estimated for each basin. Calculated storm flows were routed through the proposed drainage system from each of the 30 drainage basins. Under these conditions, approximately 61 cubic feet per second (cfs) or 27,000 gpm of storm runoff will flow from the Zoo during a 5-year storm. The wet weather design flow for the system also includes peak restroom flow, infiltration, washdown water, pool drainage (two largest from each branch of the system simultaneously), filter backwash (two largest from each branch) and flows from upstream of the Zoo. This results in a peak design flow of approximately 89 cfs or 40,000 gpm at the proposed wet weather lift station.

DESIGN CRITERIA

The design criteria used during preliminary design were based upon the City's subdivision regulations with modifications requested by City staff to account for special conditions at the Zoo such as control of sand and runoff from exhibit areas. The criteria are presented in Table 2-2.

TABLE 2-2
SUMMARY OF SEWER/DRAINAGE SYSTEM MODELING PARAMETERS

Category	Parameter	Value/Assumption
Pipe Design Criteria	Manning "n" value	0.013
	Minimum velocity	Average flow: 2.5 fps Peak flow: 3 fps
	Minimum diameter	Sewer Lateral: 10-inch Sewer main: 12-inch
	Maximum depth/diameter ratio	0.50 (half full) for average 0.8 for wet weather flow (5-year storm)
	Minimum cover	4 feet
	Minimum slope	Lateral/Culvert: 2% Main: 0.3%
	Minimum spacing	Manholes: 300-400 feet Catchbasins: 600 feet
Sanitary Flow	Design flows by subbasin	Average day and maximum day
	Shape of hydrograph	Diurnal curve to represent Zoo flow patterns
Stormwater Flow	Design flow by subbasin	Five-year storm; peak flow by Rational Method
Infiltration/Inflow	Infiltration representation	0.003 cfs/acre
Wet Weather Lift Station Control Elevation	Maximum Water Surface Elevation in Westside Transport for gravity flow	-15.5 feet MSL

DESIGN CONSTRAINTS/ASSUMPTIONS

The proposed Zoo combined sewer system as presented herein satisfies the primary design objectives and criteria. However, in order to accomplish these goals, the following design assumptions were made:

- Based upon information from the City, the water elevation in the Westside Transport varies from below -20 feet mean sea level (MSL) during dry periods to a maximum of +10 feet MSL during very wet periods. During dry periods, the Zoo system will flow by gravity into the transport. However, during large storms, when the water elevation in the Westside Transport rises above the Zoo's proposed discharge pipe (elevation -15.5 feet MSL, as shown in Table 2-2), it will be necessary to pump the Zoo flow into the transport. Therefore, a wet weather lift station is proposed. The discharge force main from the lift

station will act as a gravity sewer when pumping is not required. The general design concept is to provide gravity drainage whenever possible, and utilize the lift station to drain the Zoo during large storm events and prohibit backflow from the Westside Transport.

- Based on the Zoo's Draft Master Plan (Portico, 1994), and to the extent that it may impact the new combined sewer system, the topography of the future Zoo will generally be the same as the existing Zoo, with the following exceptions:
 - ♦ The north side service road will be constructed at a lower elevation than the existing grade.
 - ♦ The new access road to the Mammal Conservation Center will be constructed at a higher elevation than the existing grade.
- A sump pump will be installed in the future Orangutan Exhibit so that the proposed exhibit moats can be drained into the system. The need for this sump pump is based on elevation data for the orangutan moat contained in the Zoo's Master Plan (Portico, 1994). Based on the Zoo's Master Plan and the proposed sewer system layout, sump pumps were not required at other new exhibits; however, the need for additional sump pumps will be reevaluated during the design of the utility corridors and new exhibits.
- Lateral sewers serving three or fewer exhibits were not included in the model, but were laid out to assure no conflicts with future facilities. The laterals were assumed to have a minimum slope of 2 percent.
- Part of the Zoo's existing northeast parking lot will flow to Sloat Boulevard and part will flow into the proposed Zoo combined sewer system.

PROPOSED FUTURE SEWER SYSTEM

The HYDRA storm and sanitary sewer analysis package was used to evaluate the proposed system. The model was first used to determine if the east side of the Zoo could be permanently drained by gravity to the sewers along Sloat Boulevard where the existing Dry Weather Pump Station (DWPS) and Central Gravity Sewer (CGS) currently discharge. Since the Zoo's proposed combined sewer system will discharge directly to the Westside Transport along the Great Highway, additional capacity will be available along the Sloat Boulevard sewers.

The model results indicated that the discharge location of the DWPS along 44th Avenue was too high to be fed from the Zoo by gravity. The discharge location of the CGS is too high to meet minimum velocity requirements, and the 21-inch-diameter sewer is too small to accept runoff from the 5-year storm event. However, it was determined that improvements to the Zoo's northeast parking lot

could be made to utilize some of the available drain line capacity along Sloat and minimize flow through the Zoo.

DESCRIPTION OF PROPOSED FACILITIES

Combined Sewer Pipelines

The HYDRA model for the Zoo's combined sewer system was developed to model all of the proposed future Zoo except for part of the northeast parking lot. The system was broken into a total of 33 sewer mains with a combined length of approximately 7,700 feet. Using the model, the system was sized to meet all of the design criteria under both flow conditions.

Because the design criteria required a minimum velocity of 2.5 fps, a single combined sewer could not provide adequate velocity, and still enable gravity drainage into the Westside Transport from all areas of the Zoo. Therefore, parallel sanitary and storm sewers are proposed along the west side of the Zoo. An alternative to the proposed parallel sanitary and storm sewers is the use of cunette pipe. A cunette pipe is a large pipe with a low flow channel; such a pipe may be able to convey both the high storm flows and low sanitary flows within the established design criteria. The use of a cunette for this portion of the system will be evaluated during the design of the utility corridors.

Figures 2-1 and 2-2 present the proposed combined sewer system with the future Zoo Master Plan and the existing Zoo. Table 2-3 presents the preliminary design information (length, diameter, slope, invert, and depths) for each of the proposed combined sewer mains. Design criteria for sewer laterals is consistent with Table 2-2.

TABLE 2-3
ZOO COMBINED SEWER SYSTEM PRELIMINARY TRUNK DESIGN

Trunk Name	Diameter (in)	Length (ft)	Slope (%)	Upstream Invert Elev.	Downstream Invert Elev.	Upstream Rim Elev.	Downstream Rim Elev.	Upstream Depth	Downstream Depth
CW-1	12	194	3.61%	30.00	23.00	38.00	30.00	8.00	7.00
CW-2	12	310	2.42%	23.00	15.50	30.00	22.00	7.50	6.50
CW-3	21	172	1.16%	15.50	13.50	22.00	21.00	6.50	7.50
CW-4	21	246	1.83%	13.50	9.00	21.00	19.00	7.50	10.00
CW-5	21	246	2.03%	9.00	4.00	19.00	11.50	14.00	7.50
CW-6	27	114	0.66%	-2.00	-2.75	11.50	10.00	13.50	12.75
A-1	15	220	3.30%	67.10	59.85	74.60	65.20	7.50	5.35
A-2	15	230	4.35%	59.85	49.85	65.20	55.20	5.35	5.35
A-3	15	275	6.04%	49.85	33.25	65.20	38.60	5.35	5.35
A-4	21	300	0.31%	32.70	31.78	38.80	39.80	5.90	8.02
A-5	21	200	0.79%	31.78	30.20	39.80	36.10	8.02	5.90
A-6	21	200	1.80%	30.20	26.60	36.10	32.50	5.90	5.90
HP-1	12	160	0.30%	-2.00	12.12	29.80	33.20	17.20	21.08
HP-2	12	325	0.30%	12.12	11.15	33.20	32.50	21.08	21.35
HP-3	30	210	0.30%	11.15	10.51	32.50	20.40	21.35	9.89
HP-4	30	300	0.61%	10.51	8.69	20.40	15.80	9.89	6.71
CE-1	15	254	1.97%	7.00	2.00	21.00	15.50	14.00	13.50
CE-2	30	262	0.95%	2.00	-0.50	15.50	15.80	13.50	16.30
CE-3	30	280	0.80%	-0.50	-2.75	15.80	10.00	16.30	12.75
CE-4	36	374	0.46%	-2.75	-4.47	10.00	17.50	12.75	21.97
CE-5	39	404	0.38%	-4.47	-6.00	17.50	5.00	21.97	11.00
E-1	18	284	1.02%	8.00	5.10	18.80	17.10	10.80	12.00
E-2	21	324	0.83%	5.00	2.30	17.10	16.20	12.10	13.90
E-3	21	360	0.61%	2.20	0.00	16.20	14.20	14.00	14.20
E-4	21	390	0.77%	-1.00	-4.00	14.20	15.00	15.20	19.00
E-5	24	388	0.52%	-4.00	-6.00	15.00	13.50	19.00	19.50
E-6	24	324	0.71%	-6.00	-8.30	13.50	5.00	19.50	13.30
E-7	45	280	0.30%	-8.30	-9.14	5.00	7.00	13.30	16.14
E-8	45	260	0.30%	-9.14	-9.92	7.00	5.00	16.14	14.92
E-9	45	120	0.30%	-9.92	-10.28	5.00	5.70	14.92	15.98
W-1	18	341	1.27%	15.18	10.83	20.80	17.00	5.62	6.17
W-2	18	400	2.49%	10.83	0.88	17.00	6.50	6.17	5.62
W-3	30	244	0.30%	-0.10	-0.83	6.50	6.20	6.60	7.03
W-4	30	160	0.30%	-0.83	-1.31	6.20	6.00	7.03	7.31
W-5	30	220	0.30%	-4.00	-4.66	6.00	5.00	10.00	9.66
W-6	33	120	0.30%	-4.66	-5.02	5.00	6.00	9.66	11.02
W-7	33	240	0.30%	-5.02	-5.74	6.00	5.70	11.02	11.44
S-1	12	341	2.19%	12.47	5.00	20.80	17.00	8.33	12.00
S-2	12	400	1.63%	3.00	-3.50	17.00	6.50	14.00	10.00
S-3	12	244	0.70%	-3.50	-5.20	6.50	6.20	10.00	11.40
S-4	12	160	0.69%	-5.20	-6.30	6.20	6.00	11.40	12.30
S-5	12	220	0.59%	-6.30	-7.60	6.00	5.00	12.30	12.60
S-6	12	120	0.67%	-7.60	-8.40	5.00	6.00	12.60	14.40
S-7	12	240	0.63%	-8.40	-9.90	6.00	5.70	14.40	15.60
M-1	54	92	0.33%	-11.70	-12.00	5.70	8.20	17.70	20.50
M-2 (Pump Station)	54	60	0.33%	-13.00	-13.50	8.20	17.00	20.50	29.50
M-3 (Force Main)	54	260	0.31%	-14.70	-15.50	17.00	20.00	31.70	35.50

Pipe Materials and Construction Methods

Proposed materials for the Zoo's combined sewer system are presented in Table 2-4.

TABLE 2-4
PROPOSED MATERIALS FOR COMBINED SEWER SYSTEM

Pipe Diameter	Slope	Material ⁽¹⁾	Expected Life
< 24 inches	< 30 percent	Vitrified clay	75 years
≥ 24 inches	all	Reinforced concrete (lined)	75 years
Discharge to Westside Transport	all	Ductile Iron (cement lined)	75 years

⁽¹⁾ Pipe class and type will be determined during the design phase based on pipe installation depth.

Most of the Zoo's new combined sewer system can be installed by direct burial. This is the most economical method. However, near the carousel, west of the proposed lift station and along Herbst Road, sewer depths will exceed 20 feet. In these areas, microtunneling and directional drilling, although possibly more expensive, may be desirable to minimize construction-related disruptions associated with direct burial techniques. The use of microtunneling and directional drilling will be evaluated further during the design of the utility corridors.

Conveyance of Non-Zoo Flows

As discussed, the proposed Zoo system will also convey non-Zoo sanitary and storm flows from the Harding Park Golf Course, the Recreation Center for the Handicapped and the State National Guard Armory. The conveyance of these flows through the Zoo to the wet weather lift station requires the following:

- New combined sewer mains to tie the non-Zoo flows into the proposed Zoo system (trunk lines designated with "A" and "HP" on Table 2-3);
- Increased sewer main diameters for the Central East ("CE") branch of the proposed system to the wet weather lift station; and
- Increased capacity for the wet weather lift station (from 76 cfs for Zoo flows only to 89 cfs for both Zoo and non-Zoo flows) and force main to Westside Transport.

Northeast Parking Lot Drainage

Currently, most of the northeast parking lot drains through the Zoo. In order to minimize the amount of flow moving through the Zoo, a new drainage plan for the parking area is recommended. The proposed improvements include:

- Two new curbs to carry runoff from the parking area to Sloat Boulevard and Skyline Boulevard.
- Approximately 207 feet of 12-inch-diameter storm sewer.
- One new catch basin, and one new manhole.

The proposed improvements are shown on Figure 2-3.

Wet Weather Lift Station

The new wet weather lift station will be located just east of the City's existing Westside Pump Station. It is anticipated that the station will operate only during large storm events. The capacity of the station will be approximately 89 cfs (40,000 gpm), which is the anticipated peak flow during a 5-year storm event.

The design philosophy for the lift station calls for operation of the lift station pumps when the water level in the Westside Transport rises and gravity flow is no longer possible. The rising water level will cause a valve at the pump station to close, preventing backflow from the Westside Transport into the Zoo. Because the gravity sewer then will be closed, flows from the Zoo will fill the lift station wet well. As the water level in the wet well rises, the pumps will operate, discharging downstream of the closed valve and utilizing the discharge pipe as a force main. City Department of Public Works staff have already begun the design for the lift station in accordance with this general design philosophy.

Typical Catch Basins

Sand and odor control are two critical issues related to the Zoo's combined sewer system. Catch basins should be designed to minimize both the potential for odor problems and the need for on-going maintenance. Drainage outlets from individual exhibits and Zoo facilities should be designed with sand or grease traps to minimize the solids and other materials which are allowed to enter the sewer/drainage system.

Parking Lot and Other Large Area Drainage

The storm drainage system for the west parking area, as well as other large areas, should take advantage of best management practices (BMPs) to reduce peak runoff and increase infiltration. Some potential storm drainage BMPs include:

- Vegetated drainage swales and/or turf block in parking medians to maximize infiltration and provide some pretreatment of runoff.
- Raised culvert inlets that allow some ponding and reduce the peak runoff.
- Porous pavement and infiltration catch basins to maximize infiltration and reduce runoff.

- Regular sweeping of the lot to reduce debris and pollutants in the system.

COST ESTIMATES

Estimates of the total probable construction cost for the sewer system improvements are presented in Table 2-5.

TABLE 2-5
PROBABLE CONSTRUCTION COST FOR COMBINED SEWER/DRAINAGE SYSTEMS

Sewer/Drainage System Facility	Estimated Direct Cost	Total Probable Construction Cost
Collection System		
Trunk sewer lines ¹	\$2,490,800	\$3,860,700
Laterals	\$811,300	\$1,257,500
Appurtenances	\$649,700	\$1,007,000
Collection System Subtotal	\$3,951,800	\$6,125,200
Drainage Improvements		
NE Parking Lot Drainage	\$40,800	\$63,200
Drainage Improvements Subtotal	\$40,800	\$63,200
Wet Weather Lift Station		
Lift Station & Control Bldg.	\$1,397,700	\$2,166,400
Wet Weather Lift Station Subtotal	\$1,397,700	\$2,166,400
Totals	\$5,390,300	\$8,354,800

¹Total probable construction cost for trunk sewer lines includes \$284,300 for conveyance of flows from Harding Park Golf Course, Recreation Center for the Handicapped and State National Guard Armory.

The estimated direct costs have been marked up with the following percentages:

- Miscellaneous items: 10 percent
- Inflation adjustment: 4 percent
- Sales tax: 8.5 percent
- Subcontractor profit and administration: 15 percent
- Contractor profit: 10 percent
- Contingency: 10 percent

The direct costs have been estimated based on recent bids on similar projects and from standard cost estimating guides. Maintenance costs, sewers within individual exhibits, and those necessary to connect future exhibits to the proposed laterals were not included in the estimates.

Costs for construction management, designer services during construction and environmental mitigation are not shown in Table 2-5 (see Table ES-2 in the Executive Summary).

OPERATION AND MAINTENANCE

The proposed combined sewer system minimizes the need for system maintenance; however, no system is maintenance-free. Table 2-6 summarizes the recommended maintenance activities and frequency.

TABLE 2-6
RECOMMENDED SEWER/DRAINAGE SYSTEM MAINTENANCE

Required Maintenance	Recommended Frequency
Catch Basin Debris Removal	Monthly from November to April
System Flushing	Annually
Lift Station Engine-Generator Startup	Monthly
Lift Station Washdown	After large storm events and at end of each rainy season

IMPLEMENTATION

One of the advantages of the Zoo combined sewer system is that almost all of the proposed system can be installed under the current Zoo configuration and still provide the required service for the future Zoo. Additionally, because the new sewers will be generally deeper than the existing system, connections between existing and new sewers can be made to eliminate the existing pump stations as soon as the new system is installed. In general, the system will be installed "from the bottom to the top" so that facilities can be used as soon as they are installed.

LEGEND

- Proposed Sewer Main
- Proposed Sewer Lateral
- Proposed Manhole/Model Node
- Proposed Manhole
- CW-1 Sewer Main Label

NOTE:

See Table 2-3 for Sewer
Proposed Sewer Lateral

Jennedy/Jenks Consultants-AGS, Inc. An Association

San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Future Sanitary Sewer System Layout Within The Future Zoo

K/J 930524 / AGS 920801
August 1995

Figure 2-1

LEGEND

- Proposed Sewer Main
- Proposed Sewer Lateral
- Proposed Manhole/Model Node
- Proposed Manhole
- CW-1 Sewer Main Label

NOTE:

See Table 2-3 for Sewer
Proposed Sewer Lateral

Kennedy/Jenks Consultants-AGS, Inc. An Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**Future Sanitary Sewer System Layout
Within The Future Zoo**

K/J 930524 / AGS 920801
August 1995

Figure 2-1

LEGEND

- Proposed Sewer Main
- Proposed Sewer Lateral
- Proposed Manhole/Model Node
- Proposed Manhole
- 1 Sewer Main Label

NOTE:

See Table 2-3 for Sewer Diameters and Slopes

Kennedy/Jenks Consultants-AGS Inc. An Association

San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Future Sanitary Sewer System Layout Within the Existing Zoo

K/J 930524/AGS 920801
August 1995

Figure 2-2

LEGEND

- Proposed Sewer Main
- Proposed Sewer Lateral
- Proposed Manhole/Model Node
- Proposed Manhole
- CW-1 Sewer Main Label

NOTE:

See Table 2-3 for Sewer
Diameters and Slopes

Kennedy/Jenks Consultants-AGS Inc. An Association

San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**Future Sanitary Sewer System Layout
Within the Existing Zoo**

K/J 930524/AGS 920801
August 1995

Figure 2-2

Kennedy/Jenks Consultants-AGS, Inc. An Association

San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Northeast Parking Lot Improvements

K/J 930524 / AGS 920801
August 1995

Figure 2-3

ELECTRICAL SYSTEM AND COMMUNICATIONS CONDUIT

INTRODUCTION

Electrical System

Currently Pacific Gas and Electric Company (PG&E) supplies power to the Zoo through a 12 kV distribution system that runs through the Zoo and eight stepdown transformers. The Zoo operates the low-voltage system supplying power from the transformers to the various buildings and exhibits. The transformers and 12 kV cable are owned and maintained by PG&E. The Zoo's low-voltage system is owned and maintained by the Zoo or by the City. A more detailed description of the existing facilities may be found in Technical Memorandum No. 1 (K/J-AGS, 1993).

Communication System

The Zoo's current communication system consists of a Pacific Bell system which currently serves the administration buildings, animal hospital and public pay telephones and an ADT, Inc. internal telephone system which links a limited number of the Zoo facilities. Due to the limited extent of the Zoo's ADT system, most of the Zoo's internal communication is currently via portable radio.

NEED FOR NEW FACILITIES

The following provides an estimate of future needs; current system deficiencies and required improvements; and cost estimates for the proposed improvements to the electrical and communications systems.

Electrical System

As discussed in this chapter there are specific areas within the Zoo's electrical system which require rehabilitation. The electrical system improvements required to meet existing Zoo needs and provide power for the Zoo's Master Plan will involve major modifications to PG&E's high-voltage system and essentially a complete replacement of the existing Zoo-owned low-voltage distribution system. The existing system does not have adequate capacity in many areas to meet the requirements of the existing and proposed facilities. Furthermore, the proposed location of new exhibits and other facilities will require relocation of portions of the existing electrical system. In addition, Hetch Hetchy Water & Power is currently evaluating a new power grid for the Zoo area.

Communications Conduit

The existing ADT system within the Zoo is in disrepair and portions of it may be disrupted by the addition of new Zoo facilities. The existing Pacific Bell system only extends to limited areas of the Zoo. In order to improve communications within the Zoo and allow for

data transmission for animal monitoring, security, research and other needs, the Pacific Bell system within the Zoo needs to be improved. As with the ADT system, portions of the Pacific Bell system will be disrupted by new construction at the Zoo.

The Zoo is currently preparing a plan for future Zoo communications. The conduit for the future system has been included in this Infrastructure Master Plan for coordination purposes.

HIGH-VOLTAGE DISTRIBUTION SYSTEM

Extensions and modifications to the high-voltage system currently are made by PG&E, sometimes with the cost charged to the City or Zoo.

It is recommended that installation and operation of the new high-voltage systems within the Zoo remain with PG&E. The primary reason is that operation of the 12 kV system would require either an in-house staff or the use of a specialized contractor who would be on-call for maintenance and other emergencies. Furthermore, PG&E is readily available in an emergency situation.

LOW-VOLTAGE DISTRIBUTION SYSTEM

The Zoo-operated system provides services to existing facilities, usually at 480 volts. In a few cases, service is at a lower voltage, such as 240/120 volts single phase or 208/120 volts three phase. Where 480-volt service is provided, motors operate at 480 volts, and a stepdown transformer has typically been installed for 120-volt supply. A continuation of this type of low voltage distribution is recommended.

STANDBY POWER

Standby power is critical for many Zoo facilities, including the animal hospital and the administration buildings. These facilities currently have manual transfer switches which allow for the connection of a portable generator in the event of a power failure.

It is not practical or cost-effective to provide for a standby generator and distribution for the entire Zoo. Therefore, it is recommended that either a small fixed generator or a transfer switch be provided at future facilities for connection to a portable generator where standby power is deemed necessary.

LOAD ESTIMATE

The estimated electric load for the facilities in the Zoo's Master Plan is tabulated in Table 3-1 and is summarized in Table 3-2.

**TABLE 3-1
ESTIMATED ELECTRICAL LOAD**

Area and Facility Description	Demand (kW)
AREA 1: Administrative Center and Feline Conservation Center	
Commissary A	18.3
Commissary B (Hay, Grain)	7.7
Administration Buildings	52.8
Recycling Facilities	1.0
Research Center (Director's House) (Existing)	5.0
Feline Conservation Center (Existing)	20.3
Parking Lot and Area Lighting	10.0
Subtotal	125.2
AREA 2: Mammal and Avian Conservation Centers and Maintenance Shops	
Maintenance & Exhibit Shops	29.3
Automotive Maintenance Shop and Garages	5.0
Horticultural Facilities	5.0
Quarantine Center	23.2
Avian Conservation Center	73.0
Mammal Conservation Center	5.0
Subtotal	147.4
AREA 3: Africa and West Parking Lot	
Food Service	1.0
African Small Mammals	53.4
Nyala	1.6
Stork	2.5
Black Rhinoceros	1.0
Giraffe, Zebra, Gazelle and Ostrich	16.5
Okapi	3.0
Replacement Well No. 6 (In design)	37.0
Parking Lot and Area Lighting	20.0
Subtotal	143.0

Area and Facility Description	Demand (kW)
AREA 4: Animal Hospital	
Animal Health Care Facility (Existing)	51 ⁽²⁾
Gorilla (Existing)	---
Patas Monkey	3.0
African Hunting Dog	1.8
Subtotal	55.8
AREA 5: Madagascar Fauna (Primate Discovery Center)	
Madagascar Fauna (Existing Primate Discovery Center)	130.0 ⁽²⁾
Chimpanzee (Existing)	-
Mandrill Baboon	3.0
Interpretive Center for Giraffes/Zebras	12.0
Restaurant (replaces Plaza Café)	11.7
Carousel (Existing)	50.0
Tram Station/Loading/Food Stand	3.0
Ticketing/Gift/Medical Facility	11.5
Subtotal	221.2
AREA 6: Wet Weather Pump Station and North Entrance	
Restrooms	0.8
Zoo Fest Area	(50 ⁽³⁾)
Ticketing (Visitor Food Service)	9.6
Mothers' Building (Existing)	14.0
Education Building	20.3
Animal Resource Center	9.0
Children's Zoo	12.0
Parking Lot and Area Lighting	20.0
Replacement Well No. 5 (in design)	37.0
Replacement Groundwater Booster Pump Station	135.0
Subtotal	257.7

Area and Facility Description	Demand (kW)
AREA 7: South American and Australian Rain Forest Exhibits	
Australian Rain Forest Building	64.5
Wallaby, Kangaroos, Emus	6.7
Koala	14.4
Cassowary	1.3
South American Rain Forest Building	102.0
Bush Dog	1.4
Tapir	20.5
Penguin, Cary	20.7
Raptor (Harp Eagle)	3.0
Red Brocket Deer	12.7
South American Gateway	28.7
Small Animal Building	20.5
Spectacle Bear	8.0
Area Lighting	4.0
Subtotal	313.5
AREA 8: East Tropical Asia	
Orangutan	12.7
Hornbill	1.8
Gibbon/Siamang	12.9
Gibbon	17.7
Aviary/Giant Squirrel	20.3
Asian Primate	20.5
Asian Otter	11.2
Kingfisher	8.0
Tram Station	0.2
Area Lighting	4.0
Terrace Café (Existing)	10.0
Subtotal	120.8
AREA 9: West Tropical Asia	
Insectarium/Reptilium	30.0
Red Panda	5.0
Himalayan Black Bear	13.7

Area and Facility Description	Demand (kW)
Takin/Prezel Awski's Horse	4.0
Siberian Tiger	12.3
Asian Small Mammals	1.4
Snow Leopard	18.2
Amur Leopard	15.2
Walk through Flight Cage	10.4
Area Lighting	5.0
Restaurant	12.0
Subtotal	127.2

⁽¹⁾ Facilities or Exhibits taken from The Portico Group report (Portico, 1994, 1994)

⁽²⁾ Metered, existing. Estimated load from meter records.

⁽³⁾ Load occurs once or twice a year, short duration, not included in total.

TABLE 3-2
ELECTRICAL LOAD SUMMARY

Area	Area Description	Load (kW)	Transformer (kVA)
1	Administrative Center - Feline Conservation Center	125.2	150
2	Mammal and Avian Conservation Centers - Maintenance Shops	147.4	225 ⁽⁴⁾
3	Africa - West Parking Lot	143.0	225 ⁽⁴⁾
4	Animal Hospital	55.8	75 ⁽¹⁾
5	Madagascar Fauna (Primate Center)	221.2	225 ⁽⁵⁾
6	North Entrance	257.7	300 ⁽⁴⁾
7	South American/Australian Rain Forest Exhibits	313.5	500 ⁽³⁾
8	East Tropical Asia	120.8	150
9	West Tropical Asia	127.2	150
	TOTALS	1,512	2,000
	Estimated Diversified Demand	1,240	

⁽¹⁾ Existing

⁽²⁾ Replaces two existing transformers

⁽³⁾ Existing 150 kVA transformer will require replacement when load increases.

⁽⁴⁾ Initial transformer installation may be smaller.

⁽⁵⁾ Existing may require replacement.

The total estimated demand in the future is 1,240 kW. Present demand for the existing Zoo facilities is 420 kW.

The demand estimates have been prepared using appropriate watts per square foot factors times the square foot area for each animal exhibit plus the estimated horsepower required for heating and ventilation, water circulation and filtration load. The watt per square foot values were based on typical values in ASHRAE/IES Design Standard 90.1-1989, which would be required by the California Energy Commission for any new design at the Zoo. The values used varied based on the type of facility. The typical watt square foot values are summarized in Table 3-3.

**TABLE 3-3
TYPICAL WATT PER SQUARE FOOT VALUES**

Facility Type	Typical Watt per Square Foot Value
Exhibits/Viewing Areas/ Interpretative Area	1.9
Holding Areas	1.5
Keeper Areas	2.0
Restrooms	1.2
Class Rooms	2.0
Offices	2.2

Separate demand estimates were made for the existing Mothers' Building, Carousel, the Primate Center, the new replacement wells, the new groundwater booster station, area lighting and parking lot lighting.

The estimated load for each facility was plotted on the Zoo Master Plan. A series of load areas were then developed, each of which would be supplied from one transformer. These proposed areas are shown on Figure 3-1. Transformer locations have been shown based on the anticipated locations of loads within a particular load area, locations of service facilities and access to PG&E; these locations will be evaluated further during the design phase. A summary of loads by area and suggested supply transformer ratings is listed in Table 3-2.

The use of pad-mounted transformers was recommended in Technical Memorandum No. 1 (K/J-AGS, 1993). This is the typical type of transformer used by PG&E for service from an underground distribution system. An increase in the load greater than the estimate for a given area can be accommodated by going to the next larger sized transformer without a significant cost increase. Foundations and high-voltage cable costs would not change. The cost of low-voltage distribution will change but this cost is a function of the load in a particular exhibit or facility.

SPECIFIC COMMENTS BY LOAD AREAS

Area 1 - Administrative Center/Feline Center

Transfer of PG&E's existing service to the new Feline Center and the Director's Residence to the Administration Center is proposed. The electrical facilities at the Feline Center are inappropriate for a public area¹. A 480-240/120 volt stepdown transformer will be required at the Feline Center and Director's Residence.

Area 2 - Mammal and Avian Conservation Centers/Maintenance Shops

The design of the distribution system and power supply for the conservation centers has been completed. High-voltage service to the area will extend from PG&E's existing underground system south of the existing Animal Hospital. Spare conduit for future communication systems will be included. This conduit will terminate in the existing employee parking lot area. Replacement of the supply transformer with a larger transformer is anticipated when the maintenance area is constructed.

Area 3 - Africa/West Parking Lot/Well #5

The primary and initial electric load in this area will be for one of the new replacement wells. This is an area where the transformer may be replaced with a higher capacity transformer as new animal exhibits are built.

Area 4 - Animal Hospital

No major changes are proposed for this area. The Gorilla Barn is currently served from the Hospital Switchboard. Several new exhibit areas can be supplied from this switchboard; however, the 208/120V supply will limit major expansion. A new switchboard will be provided to replace the existing switchboard which is corroding.

Area 5 - Madagascar (Primate Center)

This facility has an existing supply transformer. Expansion in this area can be provided from the existing switchboard in the Primate Center Building. The Master Plan indicates that the existing café will be eliminated and replaced by a new restaurant. The new service will be provided directly from the existing transformer. The existing Carousel will be transferred to the Primate Center supply transformer along with proposed service to new facilities to the west of the Primate Center.

¹ A small PG&E pad-mounted transformer is now installed adjacent to a public walk. Next to this is a freestanding plywood panel with exposed sheet metal electrical enclosures interconnected by conduit. This installation is subject to corrosion and is aesthetically unsatisfactory.

Area 6 - Groundwater Booster Pump Station/ Mother's Building/ Ticketing/ Education Building

Construction of the proposed Education and Animal Resource Center will disrupt the existing 12 KV duct bank that now provides service to the PG&E transformers serving the existing irrigation pump station, wells and booster pump station, the Mother's Building, Ticket Kiosk and Carousel. The existing transformers shall remain until the new buildings are built. At this time, a new transformer is proposed between these buildings with new feeders to Switchboard B, the existing irrigation pump house (if still in service) and the new booster pump station and Well No. 5.

Area 7 - South America/Australia

The existing transformer and Switchboard A in the existing Wet Weather Pump Station will be retained. The transformer and switchboard now supply the bulk of the existing animal exhibits in the present Zoo. The switchboard is new and the physical arrangement permits easy installation of new conduit and wire for new animal exhibits. This facility must be kept in service to supply the existing exhibits during the transition to the new Zoo Master Plan. The transformer may require replacement as new facilities are added.

Areas 8 and 9 - East Tropical Asia/West Tropical Asia

These areas will require new supply transformers, conduit and wire. Proposed transformer locations are adjacent to Herbst Road and adjacent to water filtration plants that are part of the new exhibits. The transformers would be supplied from the adjacent PG&E overhead line on Herbst Road.

DESIGN CRITERIA

Table 3-4 summarizes the recommended materials for improvements to the electrical and communication systems.

TABLE 3-4
RECOMMENDED MATERIALS FOR
ELECTRICAL AND COMMUNICATIONS SYSTEM IMPROVEMENTS

Item	Recommended Material
Conduit, Underground	Single Runs: PVC, Schedule 40 Multiple Runs: PVC DB-120
Conduit, at Stub-Ups	Rigid galvanized steel, Schedule 40, either PVC-coated rigid steel or for low importance isolated locations, field-wrapped with 10-mil PVC tape at least 12 inches above and below the surface.
Conduit, Fittings, Wiring Device Boxes, Exterior and Well Locations	Malleable iron galvanized, with malleable iron covers, neoprene gaskets and stainless steel screws. Use bodies with PVC coating where conduit has similar coating.
Enclosures, Exterior, Small	NEMA 4 or 4X, plastic or fiberglass reinforced plastic, field painted with color to match surrounding area.
Enclosures, Exterior, Large or Free-Standing	NEMA 3R, 4 or 4X, depending on availability, fiberglass reinforced plastic or stainless steel. If enclosure has lights or pushbuttons, use boots on wiring devices. Provide space heaters.
Metering	At new major switchboards or building services, provide a voltmeter and ammeter, or alternatively a metering unit similar to Westinghouse 1Q1000 with ports for future remote monitoring. (This is in addition to PG&E metering.)
Lighting Fixtures, Exterior	High-pressure sodium-vapor, energy-efficient, high-power factor ballasts, enclosed and gasketed enclosure, stainless steel hardware. Architectural or animal requirements may dictate a different type of fixture. Recommend that exterior lights be classified as meeting the requirements of UL 543; also, in washdown areas, or exposed to incoming ocean air.
Motors	Premium type, TEFC for horizontal outdoor motors; WP-1 for vertical motors, cast-iron enclosures, cast-iron terminal boxes, with space heaters, stainless steel hardware; extra dips and bakes on windings.
Transformers, High-Voltage, Exterior	Oil-filled, pad-mounted type (typically used by PG&E). As an alternate, if appearance is an issue, subsurface type in a handhole, or underground commercial transformers in a vault.
Distribution Voltages	480, 3-phase.
Utilization Voltages	460, 230, 200 or 115.
Interrupting Capacity of Protective Devices	14,000 amperes at 480 volts, minimum

SYSTEM IMPROVEMENTS

The impact of required improvements to PG&E's existing system is shown on Figure 3-3. A proposed single line diagram of PG&E's system that would be needed for the Zoo's Master Plan is shown on Figure 3-4.

Specific system improvements within the Zoo's existing system are described below:

- Replacing Distribution Switchboard B (behind the Mother's Building);
- Replacing Distribution Switchboard H (Animal Hospital);
- Simplifying metering throughout the Zoo;
- Providing power supply to new Mammal and Avian Conservation Centers and replacement wells;
- Relocating an existing PG&E duct bank as part of the Education and Animal Resource Buildings; and
- Installing conduit as part of the proposed utility corridors for future communications systems, and high and low voltage distribution.

A discussion of each of these proposed improvements is provided below.

- A. Switchboard B. The existing switchboard, which also includes an adjacent free-standing metering structure, is an outdoor type. Roof and sides are corroding badly and require replacement.
- B. Replacement Switchboard H. This switchboard is outside of the Animal Hospital. The switchboard is corroding badly on the exterior. Ultimately, the sheet metal will corrode to the point where water will enter and cause failure. The switchboard is also now filled to capacity. A new switchboard will provide circuit breaker space and capacity for near-term additions and for the future Zoo. The new switchboard should be installed in a reinforced fiberglass enclosure.
- C. The Education Building and Animal Resource Center requires relocation of PG&E's 12 kV duct bank from Sloat Boulevard to the transformer at the existing irrigation pump house and to the transformer adjacent to the Mothers' Building. The new duct bank will probably be built in the Sloat Boulevard sidewalk. Temporary service will be required to the existing Irrigation Pump House. Service to the Westside Pump Station may also be temporarily disrupted.
- D. Meter Simplification. Simplifying the existing metering system will reduce the Zoo's administrative costs and energy costs. The Zoo now has 18 watt-hour meters. The Zoological Society is charged by PG&E at commercial rates for energy used at three

services; the Terrace Café, the Train Kiosk (in the existing Service Building) and the Sea Lion Exhibit. Estimated average monthly charge is \$459; the average cost is \$0.10 to \$0.15 cents per kilowatt hour. The energy use on all other meters is charged by Hetch Hetchy at the current rate of \$0.029/kilowatt hour.

Eliminating the three meters where PG&E currently bills the Zoo is very simple. The meter in the Service Building will require minor reconnection in the electric room of the Service Building. Removal of the meters will be done by PG&E. Reconnecting circuits can be done by an in-house electrician. These improvements are currently being implemented in coordination with Hetch Hetchy.

The new switchboard which replaces existing Switchboard B, will eliminate three meters. The remaining excess meters can be removed as part of construction facilities for the Zoo Master Plan. Ultimately, the number of meters can be reduced to nine (one per supply transformer).

- E. High Voltage Duct Bank - Avian and Mammal Conservation Centers. Installation of this duct bank will permit PG&E to provide service to the Avian and Mammal Conservation Centers and ultimately to the maintenance facilities to the north of the conservation centers.
- F. High Voltage Duct Bank for Well No. 6. The site for replacement Well No. 6 is quite remote from existing power supplies. The proposed location is south of the existing Animal Resources Center. A new high voltage duct bank is proposed to serve this area so that PG&E can install a transformer at the well. Ultimately, the new load from the future exhibits in this area will be supplied from this transformer.
- G. Utility Corridor. A new duct bank will be installed in part of the utility corridor. Conduit in the duct bank will be provided for internal communication and security systems, low voltage power, Pacific Bell and high voltage power from PG&E. The duct bank installation will only be completed within the designated utility corridors and will be via direct burial. They will have to be extended to individual exhibits when they are built. The general location of the new duct bank is shown on Figure 3-5.

The proposed communications conduit alignment is based on the proposed location of the new Administration Center, which is also assumed to be the communications center for the Zoo. Conduit will be provided for internal telephone, security and closed circuit television. One spare conduit will be included.

The conduit for Pacific Bell is intended for installation of pay telephones and other facilities that will require direct lines into Pacific Bell's system. (Terrace Café, Wet Weather Pump Station, for example.)

A small amount of high-voltage conduit will also be provided to replace PG&E's high voltage system that must be relocated because of new facilities. Conduit will be

provided in selected locations for the supply. PG&E has requested two conduits for power and a third for their own energy management system.

Conduit will be supplied for low voltage distribution (480 volts) to new facilities. The low voltage conduit will be provided where it can be readily extended to a supply transformer or to proposed exhibits that are close enough to justify the conduit run. Manholes or handholes will be provided where future extensions are likely.

Table 3-5 provides the estimated duct bank requirements proposed herein. Conduit for any area (street) lighting has not been provided. Normally, area lighting is supplied from the closest panel or switchboard, which would be the individual power supplies developed for each of the proposed Zoo facilities.

**TABLE 3-5
ESTIMATED DUCT BANK REQUIREMENTS⁽¹⁾**

System	Conduit Quantity	Estimated Lineal Feet ⁽²⁾
Electrical System Conduit		
PG&E High Voltage	2-4" conduits	7,800
Low Voltage	4" conduit (quantity varies)	4,300
Communications Conduit		
Pacific Bell	1-4" conduit	4,100
Internal Zoo Communications	4-4" conduits	12,500

⁽¹⁾ A duct bank consists of a number of conduits grouped into a common trench or encasement.

⁽²⁾ Estimated lineal feet shown is total for all conduits.

COST ESTIMATES

Estimates of the total probable construction cost for the electrical and communications systems improvements are presented in Table 3-6.

**TABLE 3-6
PROBABLE CONSTRUCTION COST FOR ELECTRICAL SYSTEM AND COMMUNICATIONS CONDUIT**

Electrical/Communication System Facility	Estimated Direct Cost	Total Probable Construction Cost
Electrical System		
Duct Bank and Conduit	\$403,000	\$624,600
12kV Appurtenances	\$25,000	\$38,800
Low Voltage Appurtenances	\$29,100	\$45,100
Electrical System Subtotal	\$457,100	\$708,500
Communication Conduit		
Conduit	\$323,900	\$502,000
Communication Subtotal	\$323,900	\$502,000
Totals	\$781,000	\$1,210,500

The estimated direct costs have been marked up with the following percentages:

- Miscellaneous items: 10 percent
- Inflation adjustment: 4 percent
- Sales tax: 8.5 percent
- Subcontractor profit and administration: 15 percent
- Contractor profit: 10 percent
- Contingency: 10 percent

The direct costs have been estimated based on recent bids on similar projects and from standard cost estimating guides.

Costs for construction management, designer services during construction and environmental mitigation are not shown in Table 3-6 (see Table ES-2 in the Executive Summary).

IMPLEMENTATION

Installation of the new electrical facilities can be done in the following sequential segments.

1. Install communications and high-voltage duct bank system to the Avian and Mammal Conservation Centers, part of the Avian and Mammal Conservation Projects.
2. Install high-voltage duct bank for replacement Well No. 6.
3. Relocate existing 12 kV duct bank.
4. Install new Switchboard B at a location adjacent to the existing.
5. Install new Switchboard H.
6. Install utility corridor duct banks in accordance with the overall utility corridor construction schedule.

The replacement of Switchboards B and H can proceed independently at any time. Meter simplification improvements are currently being implemented in coordination with Hetch Hetchy.

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Zoo Infrastructure Master Plan

Electrical System Proposed Load Areas

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Figure 3-1

LEGEND

▲ EXISTING TRANSFORMER

▲ PROPOSED TRANSFORMER

REMOVE

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Electrical System Proposed Load Areas

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Figure 3-1

NOTES:

1. ZOO POWER SYSTEM IS SUPPLIED FROM 12 KV CIRCUIT 1106, DALY CITY SUBSTATION.
2. 12 KV SYSTEM IS UNDERGROUND WITHIN THE ZOO GROUNDS.

LEGEND

- FUSE
- SECTIONALIZING SWITCH
- TRANSFORMER

WELL NO. 6 (IN DESIGN)

MAMMAL CONSERVATION CENTER
AVIAN CONSERVATION CENTER
(UNDER CONSTRUCTION)

TO BE REMOVED → T4060
25 KVA

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Electrical System
Modifications to Existing PG&E System
Future Zoo

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Figure 3-2

NOTES:

1. ZOO POWER SYSTEM IS SUPPLIED FROM 12 KV CIRCUIT 1106, DALY CITY SUBSTATION.
2. 12 KV SYSTEM IS UNDERGROUND WITHIN THE ZOO GROUNDS.

LEGEND

- FUSE
- SECTIONALIZING SWITCH
- Transformer

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Electrical System
Modifications to Existing PG&E System
Future Zoo

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Figure 3-2

E LEGEND

- FUSE
- SECTIONALIZING SWITCH
- TRANSFORMER
- EXISTING
- PROPOSED CHANGES

OVERHEAD
DISTRIBUTION
IN TARAVAL
DISTRICT

AI
FI

OVERHEAD TO
LAKE MERCED AREA

CABLE TO
OCEANSIDE WATER
POLLUTION CONTROL PLANT

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Electrical System
Proposed PG&E 12KV System
Future Zoo

K/J 930524 / AGS 920801
August 1995

Figure 3-3

NOTES:

1. ZOO POWER SYSTEM IS SUPPLIED FROM 12 KV CIRCUIT 1106, DALY CITY SUBSTATION.
2. 12 KV SYSTEM IS UNDERGROUND WITHIN THE ZOO GROUNDS.

LEGEND

- FUSE
- SECTIONALIZING SWITCH
- TRANSFORMER
- EXISTING
- PROPOSED CHANGES

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Electrical System
Proposed PG&E 12KV System
Future Zoo

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Figure 3-3

INTERNAL TELEPHONE, SECURITY)

12 KV)

CIFIC BELL)

ANKS TO BE INSTALLED AS PART
RVATION CENTERS.

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Electrical System Proposed Duct Bank Locations

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Figure 3-4

NATURAL GAS SYSTEM

INTRODUCTION

Currently Pacific Gas and Electric Company (PG&E) supplies natural gas to the Zoo through two existing buried natural gas mains running through the Zoo which terminate at a number of metered service points within the Zoo. In addition, the Zoo operates additional gas lines within the Zoo that service other existing facilities without individual meters. The gas lines up to the meters and the meters themselves are owned and maintained by PG&E. The lines which extend beyond the PG&E meters are owned and maintained by the City for the Zoo.

The following section describes the preliminary design of the Zoo's future natural gas distribution system including the need for new facilities, estimated gas loads, design criteria, system improvements, system costs and implementation strategies.

NEED FOR NEW FACILITIES

With the proposed future Zoo layout and the proposed utility corridors for the Zoo's new utilities, some of the existing Zoo-owned gas lines will no longer be required. Some of these gas lines will be required to remain in service until the existing Zoo facilities are decommissioned. However, some of these lines have deteriorated due to age and corrosion and will need to be replaced to ensure that the existing facilities are adequately and safely served until decommissioned. Numerous gas leaks were discovered following the 1989 earthquake and many additional leaks have been identified since then.

To adequately serve the future Zoo facilities, modifications to portions of the PG&E's existing gas distribution system within the Zoo will be required. The locations of proposed new exhibits and other facilities will require relocation and, in some cases, extension of existing PG&E gas lines. It is proposed that PG&E provide gas service to any new facilities and that the Zoo operate and maintain only the exposed pipes within the exhibit or facility.

ESTIMATE OF GAS LOADS

The estimated gas loads for the Zoo were developed based on The Portico Group's San Francisco Zoo Draft Master Plan (Portico, 1994) which describes in detail the areas and the facilities to be heated. The estimated gas loads required for each area designated in the Zoo Master Plan are given in Tables 4-1, 4-2 and 4-3.

**TABLE 4-1
NATURAL GAS LOAD IN THE SUPPORT SERVICES AREA**

METER NUMBER	BUILDING AREA	SQUARE FEET	HEAT LOAD (MBH)		
			O.A.	BLDG ENV	TOTAL
M7	Administration Building	16600	125	75	200
M6	Research Center	2400	16	16	32
M8	Animal Health Care Facility (Existing)	12800	75	96	171
M8	Commissary (Building A)	8200	71	41	112
M8	Commissary (Building B)	4600	57	26	83
M8	Visitor Food Service Storage	4800	36	27	63
M3	Maintenance and Exhibits Shops	7400	88	38	126
M3	Automotive Maintenance and Garages	6650	29	35	64
M11	Recycling Barn	4600	20	14	34
M1	Horticulture Department	6000	33	19	52
M9	Incinerator				3600
	Totals	74050		Output	4537
				Input	5450

O.A. Outside Air
 BLDG ENV Building Envelope
 MBH Thousand BTU per hour
 Input = Output x 1.2

**TABLE 4-2
NATURAL GAS LOAD IN THE CONSERVATION AND QUARANTINE FACILITIES**

METER NUMBER	BUILDING AREA	SQUARE FEET	HEAT LOAD (MBH)		
			O.A.	BLDG ENV	TOTAL
M2	Quarantine Center	15000	78	35	113
M4	Avian Conservation Center	25130	126	50	176
M5	Mammal Conservation Center	2688	230	120	350
M16	Feline Breeding Center	3500	13	23	36
	Totals	46318		Output	675
				Input	810

O.A. Outside Air
 BLDG ENV Building Envelope
 MBH Thousand BTU per hour
 Input = Output x 1.2

**TABLE 4-3
NATURAL GAS LOAD IN THE EXHIBITS**

METER NUMBER	BUILDING AREA	SQUARE FEET	HEAT LOAD (MBH)		
			O.A.	BLDG ENV	TOTAL
	AFRICA EXHIBITS				
M13	Stork	600	0	90	86
M13	Gorilla	19050	0	27	27
M17	Giraffe, Zebra, Gazelle & Ostrich	9750	0	12	12
M15	Chimpanzee	4400	0	12	12
M13	Black Rhino & Maribou Stork	1200	0	0	5
M13	African Hunting Dog	600	0	0	3
M17	Small Mammals and Satellite Classroom	16790	78	24	152
M13	Patas Monkey	1500	0	8	7
M15	Madagascar Primates	10830	0	24	20
M15	Mandrill Baboon	1500	0	8	4
M13	Nyala or Lechwe	900	0	4	4
M17	Okapi	1500	0	6	6
	AUSTRALIA EXHIBITS				
M28	Wallabys, Roos & Emu	2000	0	11	11
M36	Koala	1600	0	90	90
M28	Cassowary	400	0	20	25
M29	Australian Rain Forest Building	16000	71	115	186
	MONTANE ASIA EXHIBITS				
M17	Amur Leopard	2950	11	12	20
M17	Small Mammals	400	0	1	4
M21	Golden Monkey	2000	14	4	18
M15	Himalayan Black Bear	1500	0	6	6
M15	Red Panda	2950	18	3	21
M17	Siberian Tiger	1600	0	5	0
M17	Snow Leopard	12185	33	8	42
M20	Takin & Przewalski's Horse	1600	0	6	6
M17	Walk Thru Flight Cage	400	0	4	4
	NORTH AMERICA EXHIBITS				
M34	Children's Zoo			20	20
	SOUTH AMERICA EXHIBITS				
M32	Bush Dog	600	0	5	5
M34	Common Tapir	1200	0	8	6
M30	Penguin & Cavy	2600	12	10	28
M32	Raptor	450	0	4	4
M32	Red Brocket Deer	1500	0	8	3
M34	South American Gateway	5209	66	20	86
M30	South American Rain Forest Building	18000	82	33	165
M31	Small Animal Building	9370	44	51	95
M32	Spectacled Bears	2800	35	6	41
	SOUTHEAST ASIA EXHIBITS				
M18	Asian Elephant	7200	0	55	55
M25	Rookery	1200	0	5	5

METER NUMBER	BUILDING AREA	SQUARE FEET	HEAT LOAD (MBH)		
			O.A.	BLDG ENV	TOTAL
M24	Asian Otter	600	0	4	4
M22	Asian Primate	9475	0	12	12
M36	Asian Lion	10060	0	7	7
M23	Aviary	5000	44	43	87
M25	Barasingha	1200	0	8	8
	Bats	500	4	10	14
M25	Blackbuck	1600	0	9	9
	Brown Fishing Owl	150	0	2	2
M23	Giant Squirrel	100	0	1	1
M27	Gibbon & Siamang	1200	0	6	6
M24	Gibbon	600	0	3	3
M26	Hornbill	100	0	2	2
M20	Indian Rhinoceros	20760	0	7	7
M24	King Fisher	1000	0	12	12
M25	Langur	1200	0	6	6
M18	Muntjac	150	0	2	2
M26	Orangutan	5075	19	20	39
	Reptiles and Fish	300	0	1	1
M21	Insect/Reptilium	10800	99	70	169
	MISCELLANEOUS AREAS				
M39	Mother's Building				225
M37	Educational Building				225
M38	Animal Resource Center				225
M35, M40, M42	Restaurants/Cafes				950
M39	Gift Shop				100
	Totals	234504		Output Input	3424 4100

O.A. Outside Air
 BLDG ENV Building Envelope
 MBH Thousand BTU per hour
 Input = Output x 1.2

In developing the loads for some of these areas, assumptions were made based on engineering judgment and standards of practice. Assumptions were also made in some instances with regard to building volumes when there was a question as to the building envelope, height and amount of open wall area. It was also assumed that animals would congregate in the warm part of an exhibit, which reduced the heated areas in the calculations.

The present load is 9,470 cubic feet per hour (CFH); the projected demand is 10,360 CFH. This represents a 10 percent increase, which is well within PG&E reserves.

As discussed, the future Zoo gas loads are based on data contained in the Zoo Master Plan (Portico, 1994). Some of the areas in which radiant heat is designated may need further evaluation during design and after the program for each facility is developed to determine

if radiant heat will be in the floors or overhead. If the final program for a facility also includes forced air heating, a gas-fired boiler with a multi-temperature hot water system will be necessary since water supply temperature for the tempered air heating coils in a forced air system is much higher than the water supply temperature for a radiant floor system.

With the future gas loads as calculated from the Zoo Master Plan, it does not appear that the Zoo qualifies (from a cost savings point of view) for bulk gas delivery, an option that was discussed in Technical Memo No. 1 (K/J-AGS, 1993). With bulk delivery, PG&E would only have responsibility for the piping up to the master gas meter at the entrance to the Zoo and the Zoo would have to maintain all gas piping on the Zoo property. The Zoo would have to provide a qualified gas system maintenance staff and establish its own gas line testing program. This latter requirement is necessary even with non-corroding buried pipe materials because the risers from the buried plastic pipe must be metal and would be susceptible to corrosion.

SYSTEM IMPROVEMENTS

The preliminary design for the proposed natural gas system to meet both the existing and future needs of the Zoo has been developed based on using PG&E's high pressure gas piping system which exists in Sloat Boulevard and Herbst Road. PG&E's piping system encloses about two-thirds of the perimeter of the Zoo and has ample capacity to meet projected loads.

Because of the adequate PG&E gas service surrounding the Zoo, a separate, new interior gas line loop within the Zoo itself is not necessary. It is proposed that PG&E bring gas service from its exterior gas mains with multiple points of connection to the proposed Zoo facilities. Once the new gas lines have entered the Zoo property, they will generally follow the already identified utility corridors being used by the water, sewer and electrical/communication systems. In areas with no common corridor, gas lines will be run in the most direct path within existing service roads and pathways.

The PG&E distribution network would be similar to the present system at the Zoo which is maintained by PG&E and in which the main pipeline runs branch to various meters where gas is needed. If PG&E regulations permit, some of the longer pipeline runs will be installed prior to the construction of the facilities they are to serve to minimize the need for future construction within the utility corridors. This proposed installation will need to be closely coordinated with PG&E during the design of the utility corridors.

In addition to new gas lines to serve new facilities, some of the Zoo's existing facilities such as the Terrace Cafe and the Mothers' Building will probably require new gas services due to the condition of the existing gas service lines and potential conflicts with the proposed utility corridors.

The layout of the existing gas piping is shown on Figure 4-1. The proposed utility corridors for the future Zoo are shown on Figure 4-2. This figure also shows the existing PG&E gas mains and extensions added by the City. Since the Zoo-owned lines have been corroding,

it is probably better to abandon them in place since PG&E will not reuse them. A portion of the PG&E lines which supplies the hospital and incinerator might be salvageable but potential interferences with the proposed utility corridors must be considered during the utility corridor design phase.

The proposed meter locations and pipe runs for the future Zoo are shown on Figure 4-3. As much as possible, the pipe runs correspond with the proposed utility corridors to minimize construction interferences. A list of proposed meters and pipelines that will be installed by PG&E is provided in Table 4-4.

**TABLE 4-4
NATURAL GAS LINE QUANTITY ESTIMATE**

LINEAL FOOTAGE OF GAS LINE (BY PG&E)									HEATING LOAD (MBH)(3)
METER	3/4 INCH	1 INCH	1 1/2 INCH	2 INCH	2 1/2 INCH	3 INCH	3 1/2 INCH	4 INCH	
M1	50								63
M2		100							136
M3		100							230
M4		50				350			212
M5				550					420
M5	100								40
M2			50						240
M3			50						515
M5								1000	4320
M10	550								15
M11	50								41
M12	100			600					190
M13	100		650						23
M14	50		1100						51
M16	300								52
M16	100		350						40
M12		300							50
M14	200								70
M16	300								33
M20	50								16
M21				600					225
M22	100		250						15
M28	50								190
M28	100		250						23
M25	300								34
M28	100	100							50
M22	250								8
M28	100								41
M28		50			600				224
M30		100							208
M31	100				400				115
M32	50								71
M33	50				650				34
M34	50								104
M30			100	400					385
M30		300							117
M32		50	100						270
M30			350						295
M30			100			400			390
M40				450					384
M41 (1)	50								190
M42 (2)			250						384
TOTAL	3250	1150	3600	2600	1650	750	0	1000	10483

- (1) For existing aviary
 (2) For existing restaurant
 (3) Thousand BTU per hour

Pipe sizes given in this table were determined conservatively in the event that PG&E uses a low pressure distribution system. During the utility corridor design phase, this proposed layout will be coordinated with PG&E regarding location, meters and the policy regarding installation of piping at present which may not be used for many years.

DESIGN CRITERIA AND MATERIALS OF CONSTRUCTION

If PG&E installs the new gas distribution system, it will be done in accordance with their design criteria and under their supervision. For those facilities to be installed by the City, beyond the PG&E meters, the recommended materials for construction of pipe, valves and accessories are shown in Table 4-5.

**TABLE 4-5
NATURAL GAS SYSTEM PROPOSED MATERIALS LIST**

Item	Material	Code Requirements/ Industry Practice
Pipe	Black steel pipe coated with plastic or polyethylene pipe	Uniform Plumbing Code with San Francisco Amendments
Valves	Steel or polyethylene	Same as pipe
Corrosion Protection	Plastic pipe or steel pipe with plastic coating; sacrificial anodes or impressed current cathodic protection	Industry practice as recommended by manufacturers and NFPA Gas Code
Earthquake Valves	Steel and aluminum with outdoor finish	Not yet required by code, but good practice
Meters and Regulators	Steel or aluminum	Not code regulated; provided by utility except where owner installs meters downstream of utility provided meters

ESTIMATED COSTS

Estimates of the total probable construction cost for the natural gas system improvements are presented in Table 4-6.

TABLE 4-6
PROBABLE CONSTRUCTION COST FOR NATURAL GAS SYSTEM

Natural Gas System Facility	Estimated Direct Cost	Total Probable Construction Cost
Natural Gas Lines	\$177,300	\$274,800
Appurtenances	\$34,100	\$52,900
Totals	\$211,400	\$327,700

The estimated direct costs have been marked up with the following percentages:

- Miscellaneous items: 10 percent
- Inflation adjustment: 4 percent
- Sales tax: 8.5 percent
- Subcontractor profit and administration: 15 percent
- Contractor profit: 10 percent
- Contingency: 10 percent

The direct costs have been estimated based on recent bids on similar projects and from standard cost estimating guides.

Costs for construction management, designer services during construction and environmental mitigation are not shown in Table 4-6 (see Table ES-2 in the Executive Summary).

IMPLEMENTATION

If PG&E regulations permit, some of the longer pipeline runs will be installed prior to the construction of the future facilities they are to serve. An option suggested by PG&E is to install carrier pipe along with the other utility systems now; then, in the future, the gas lines can be installed within the carrier pipe without the need for trenching.

Some of the Zoo's existing facilities such as the Terrace Cafe and the Mothers' Building will require continuous gas service. Coordination will be required with PG&E since the proposed reconstruction of the existing gas system may disrupt their current point of connection to the existing gas distribution system.

g Gas Line (PG&E)

g Gas Line (Zoo)
Abandoned)

ed Routing Location

existing gas lines
Building is unknown.

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**Layout of Existing
PG&E and Zoo Gas Lines**

K/J 930524/AGS 920801
August 1995

Figure 4-1

Gas Line (PG&E)
 Routing Location
 Gas Line (Zoo
 Abandoned)
 Utility Corridors

Existing gas
 s Building

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 Zoo Infrastructure Master Plan

**Layout of Existing PG&E and Zoo Gas Lines
 and Utility Corridors**

K/J 930524 / AGS 920801
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Figure 4-2

Kennedy/Jenks Consultants-AGS, Inc. An Association
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Zoo Infrastructure Master Plan

**Layout of Existing PG&E and Zoo Gas Lines
and Utility Corridors**

K/J 930524 / AGS 920801
August 1995

Figure 4-2

and PG&E Gas Line

and Modification to Exist. Gas Line

and Gas Meter Location
(able for Gas Load)

Connection to Main PG&E Line at
Road and Sloat Boulevard

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Layout of Proposed PG&E Gas Lines and
Modifications to Existing Gas Lines

K/J 930524 / AGS 920801

August 1995

Figure 4-3

LEGEND

- Proposed PG&E Gas Line
- Proposed Modification to Exist. Gas Line
- Proposed Gas Meter Location (See Table for Gas Load)
- Connection to Main PG&E Line at Herbst Road and Sloat Boulevard

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San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

Layout of Proposed PG&E Gas Lines and
Modifications to Existing Gas Lines

K/J 930524 / AGS 920801
August 1995

Figure 4-3

REFERENCES

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Examination: Evaluation

APPENDIX A:

**NEGATIVE DECLARATION FOR SAN FRANCISCO ZOO
INFRASTRUCTURE REPLACEMENT**

1. Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the participants. The study was conducted in a controlled environment and the results are presented in the following sections.

**City and County of San Francisco
The Planning Department**

**1660 Mission Street
San Francisco, CA 94103-2414**

NEGATIVE DECLARATION

Date of Publication of

Preliminary Negative Declaration: November 18, 1994

**Lead Agency: City and County of San Francisco, Dept. of City Planning
1660 Mission Street, San Francisco CA 94103**

Agency Contact Person: Paul Maltzer Telephone: (415) 558-6391

**Project Title: 94.366E, San Francisco Zoo Project Sponsor:
Infrastructure Replacement S.F. Dept. of Public Works**

Project Contact Person: Karen Kubick (415) 554-8206

Project Address: 1 Zoo Road, Between Sloat Blvd., Zoo Rd., The Great Hwy.

Assessor's Block(s) and Lots(s): 7281 / 6,7

City and County: San Francisco

Project Description: The Proposed project is the replacement of the earthquake damaged water, gas, electric and sewer systems at the San Francisco Zoo. Utility lines would be installed underground in a utility corridor with lateral lines connecting to Zoo exhibits and facilities. Above-ground systems would be limited to mechanical and electrical equipment (booster pumps, valves, switch gears). The two existing groundwater wells would be replaced with two new wells within the Zoo. The existing Avian Center would be relocated to a site within the Zoo (adjacent to the National Guard Armory) to mitigate for potential noise and dust impacts to sensitive birds.

Building Permit Application Number, if applicable: Not Applicable

THIS PROJECT COULD NOT HAVE A SIGNIFICANT EFFECT ON THE ENVIRONMENT. This finding is based upon the criteria of the Guidelines of the State Secretary for Resources, Sections 15064 (Determining Significant Effect), 15065 (Mandatory Findings of Significance) and 15070 (Decision to Prepare a Negative Declaration), and the following reasons as documented in the Initial Evaluation (Initial Study) for the project, which is attached.

Mitigation measures, if any, included in this project to avoid potentially significant effects: (1-8, See Text)

Final Negative Declaration adopted and issued

on

December 22, 1994

In the independent judgement of the Department of City Planning, there is no substantial evidence that the project could have a significant effect on the environment.

Barbara W. Sahm

BARBARA W. SAHM

Environmental Review Officer

cc: Robert Passmore

Pedro Arce

Project Sponsor

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(415) 558-6414**

**PLANS AND PROGRAMS
(415) 558-6264**

**IMPLEMENTATION/ZONING
(415) 558-6377**

PROJECT SETTING:

The proposed project site is within the San Francisco Zoological Gardens, located in the southwest part of the City along The Great Highway, between Sloat Boulevard and Zoo Road (see Figure 1, Project Location Map). The 125-acre site is on property zoned P (Public Use District), which is under the jurisdiction of the San Francisco Recreation and Park Department and leased to the San Francisco Zoological Society. The site is within the OS (Open Space) Height and Bulk District and the Coastal Zone.

Surrounding land uses are residential/commercial development to the north and east of the site; the California Army National Guard Armory on the south-west corner of the property; the Oceanside Water Pollution Control Plant on a site jointly used with the Zoo just south of Zoo Road; the Recreation Center for the Handicapped south of Zoo Road; Harding Park Golf Course and Lake Merced recreational facilities to the south and southeast; and Golden Gate National Recreation Area ocean-beach to the west.

PROJECT DESCRIPTION:

Purpose of the Proposed Project: The Zoo has utility systems over 70 years old. The 1989 Loma Prieta earthquake severely damaged the utility systems at the Zoo, partially because of their age and partially because they were not designed to withstand lateral forces such as those exerted by the earthquake. Interim repairs to the damaged utilities have been made; however, the entire system has developed "weak" points and major system failures continue to occur. For example, the existing water wells are vulnerable to failure because of deteriorated well casings. Potential failure of the water, gas, electric or sewer systems at the Zoo would place the animals (some threatened and endangered) and Zoo visitors and employees at risk.

The Proposed Project: The proposed project is the replacement of the water, gas, electric and sewer systems at the San Francisco Zoo. Utility lines (including electrical conduits) would be installed underground. Above-ground systems would be limited to mechanical and electrical equipment (booster pumps, valves, switch gears, backflow protectors) required to meet applicable codes and regulations. Above-ground equipment would be contained in protective enclosures to prevent corrosion and tampering. Below-ground utility systems would include: domestic water and reclaimed water* pipelines; ground water and natural gas pipelines; electrical, sanitary, storm and combined sewer pipelines. An existing groundwater reservoir would be covered. The two existing groundwater wells would be abandoned and filled in accordance with the Department of Water Resources Bulletin 74 Well Standards. The Zoo would remain open to the public throughout construction.

The above utility systems as they exist in 1994 are shown in Figure 2. The replacement systems would serve the same uses at the Zoo as the existing system. A Master Plan for the Zoo to the year 2000 has been under development by the Zoological Society, in consultation with the Recreation and Park Department since 1988. The Master Plan will be subject to environmental review when it is proposed for City approval. Due to the uncertainty over the timing of the Zoo Master Plan project, as well as due to the deteriorating condition of the existing infrastructure, the City has proposed this replacement project now. The Zoo Master Plan would need to address any potential changes to the proposed infrastructure as a result of the Master Plan, if necessary.

* See Note to Water Use for the Zoo Table, at p.20, below.

FIGURE 1: PROJECT LOCATION

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LEGEND:

WATER

5" PIPELINE
2 1/2" PIPELINE
REDUCED PRESSURE
BACKFLOW PREVENTER (RPBP)

SEWER/STORM

HARDING PARK SANITARY SEWER
SKYLINE-SUNSET OUTLET SEWER
200 SANITARY SEWER
CENTRAL GRAVITY STORM SEWER
EAST SIDE STORM SEWER
WEST SIDE STORM SEWER
CONNECTION

ELECTRIC/GAS/ALARM/TELEPHONE

ELECTRICAL CONDUIT
GAS LINE
OVERHEAD TELEPHONE LINE
PG&E - 12 KV
200 DISTRIBUTION - 480V

Kennedy/Jenks Consultants-AGS Inc. An Association
San Francisco Zoo Garden
Zoo Infrastructure Master Plan

Existing Utilities Systems

23 May 1994

Figure 2

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The proposed project is a utility corridor internal to the Zoo (see Figure 3). Lateral lines, as exist in 1994, would connect the utility corridor with exhibits and buildings. A 500 foot segment of sewer along Sloat Blvd. would replace the existing Zoo connection to the Westside Transport.

Construction staging is proposed for the Fleishhacher Pool parking area, with access off Zoo Road and Skyline Boulevard (see Figure 3).

Because of its sensitivity to noise, the existing Avian Center located adjacent to the proposed staging area, groundwater well and reservoir is proposed to be relocated to a new site within the Zoo to mitigate for construction related impacts from the infrastructure project. A relocated Avian Conservation Center (ACC) is proposed as part of the project, to be located west of Park Road and adjacent to the Armory (see Figure 4). The planned ACC facility would be about 46,000 square feet (1.06 acres) and would consist primarily of: wire-mesh holding, fledging and breeding enclosures; incubation and hatching facilities; and a work and administration building to house video monitoring equipment, food storage and animal diet preparation kitchen (about 1,600 square foot, single story wood building). The ACC would have limited public access (escorted special tours), would be ADA accessible and would include space for programming a future Condor Rearing facility that would be privately funded.

A Mammal Conservation Center, located on the joint-use area above the Oceanside Water Pollution Control Plant (addressed in the Southwest Sewage Treatment Facility Final EIR, 85.484E, March 10, 1988), would be used as a holding area for animals that need to be relocated from exhibit areas during utility replacement (see Figure 4).

The Department of Public Works (DPW) of the City and County of San Francisco has responsibility for designing and implementing this project. The following goals and objectives were established by DPW for the project:

- Elimination of existing potential public health risks including cross connection of potable and non-potable water and sewer overflow problems. Zoo utility systems would be brought into compliance with California Administrative Code Title 17 for proper backflow prevention practices.
- Meeting the San Francisco Water Department (SFWD) water use goals for the Zoo through use of reclaimed water (if and when available).
- Compliance with the Board of Supervisors' Ordinance 391-91 by connecting the existing irrigation system to the Oceanside Water Pollution Control Plant reclaimed water.
- Increase in water quality and reliability of the groundwater system at the Zoo through design and implementation of a covered storage reservoir.
- Meeting 1994 California Department of Water Resource's well standards (pursuant to Bulletin 74-90) for sanitary well seals and monitoring. Replacement wells would be monitored for flow rate, drawdown, total extraction and water quality.
- Minimization of use of Hetch Hetchy water. The Zoo would have a water system utilizing the best available technology, which would in turn serve to educate the public about water conservation and water reclamation.

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See Table 2-3 for Sewer
Diameters and Slopes

San Francisco Zoological Garden
Zoo Infrastructure Master Plan

**Schematic Layout of Future Utility Corridors
Within the Existing Zoo**

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- Elimination of frequent maintenance of sanitary and storm water systems because of pipe deterioration and improper sizing.
- Provision for emergency power for the wastewater pump systems so that flooding problems could be minimized.
- Design of the natural gas system to withstand the corrosive environment at the ocean.
- Design of the new utility systems for ease of maintenance. There would be flexibility in the systems so that if utility sections must be closed in the future for maintenance, the Zoo would not need to be shut down.
- Location of utility systems access points to minimize disruption to public areas and sensitive animal exhibits during routine maintenance of utilities.
- Minimization of disruption to the animals and to Zoo visitors during construction through implementation of specific mitigation measures. Mitigation would include monitoring to verify its effectiveness and reporting to the City and to the Zoo Task Force on a monthly basis. Construction would be phased to minimize disruption during sensitive breeding seasons for animals and to minimize disruption during peak visitor times. The Mammal Conservation Center and Avian Conservation Center have been designed as holding areas for animals during construction of the utility systems. (see Mitigation Measure Number 1)

In 1990 San Francisco voters passed the Earthquake Safety Program Bond Issue for City-Owned Facilities, Phase II (ESP2). The Bond Issue included utilities at the San Francisco Zoological Gardens (Zoo), providing for replacement of earthquake-damaged and deteriorated water, gas, electrical and sewer systems. Funds made available by the Bond Issue must be expended three years after they are sold. The next bond sale is anticipated for April 1995. The proposed project would make use of these funds. Final authorization for expenditure of these funds must be made by the Board of Supervisors.

Project Schedule: Pre-design of the Zoo infrastructure began in September of 1993. Pre-design has consisted of the preparation of technical reports (Kennedy-Jenks/AGS, 1994) which have been reviewed by the Infrastructure Project Steering Committee, Peer Review Committee and Joint Zoo Committee. An Infrastructure Master Plan will finalize the proposed project based on the results of the technical studies and the information contained in the environmental review document.

Should the project ultimately be approved, the final design and specifications for the infrastructure project would follow environmental review. Design is anticipated to take about 12 months and would include the replacement wells and Avian Conservation Center as the first priority for the project. These two facilities are planned for construction in early 1995. The phased construction of the other infrastructure replacements would take place over a two to three year period. The schedule for construction in specific areas of the Zoo has been developed to minimize potential impacts to Zoo animals and visitors.

PLANS AND POLICIES

Environmental Plans and Policies are those, like the Bay Area Air Quality Plan, which directly address physical environmental issues and / or contain targets or standards which must be met in order to preserve or improve characteristics of the City's physical environment. The current proposed project would not obviously or substantially conflict

with any such adopted environmental plan or policy. Should the project be approved, a Mitigation Monitoring Plan would be included as part of the approved project to ensure compliance with the California Environmental Quality Act (CEQA), Section 21081.6 (Added, Chapter 1232, Statutes of 1988).

The San Francisco *Master Plan*, which provides general policies and objectives to guide land use decisions, contains some policies which relate to physical environmental issues. The proposed project would not obviously or substantially conflict with any such policy. In general, potential conflicts with the *Master Plan* are considered by the decision makers (Recreation and Park Commission, and City Planning Commission) independently of the environmental review process, as part of the decision whether to approve, modify or disapprove a proposed project. Any potential conflict not identified here could be considered in that context, and would not alter the physical environmental effects of the proposed project.

Of particular relevance to the proposed project is Policy 3 of Objective 4 within the City's Recreation & Open Space Element of the *Master Plan* (July 1987) to "Renovate and renew the City's parks and recreation facilities". This policy includes a provision for infrastructure, landscape elements and facilities to serve the intended users and to facilitate ongoing maintenance.

In November 1986, the voters of San Francisco approved Proposition M, the Accountable Planning Initiative, which added Section 101.1 to the City Planning Code to establish eight Priority Policies. These policies are: preservation and enhancement of neighborhood-serving retail uses; protection of neighborhood character; preservation and enhancement of affordable housing; discouragement of commuter automobiles; protection of industrial and service land uses from commercial office development and enhancement of resident employment and business ownership; maximization of earthquake preparedness; landmark and historic building preservation; and protection of open space. Prior to issuing a permit for any project which requires an Initial Study under CEQA or adopting any zoning ordinance or development agreement, the City is required to find that the proposed project is consistent with the Priority Policies.

POTENTIAL ENVIRONMENTAL EFFECTS: DISCUSSION OF ATTACHED CHECKLIST

The proposed project site is located in the Zoological Gardens on land used for recreation purposes since 1922, when the City acquired 60 acres from the Spring Valley Water Company. The San Francisco Zoo was founded in 1929 as part of the larger recreational complex. Surrounding land uses are shown on Figure 5 and include: the National Guard Armory on the southwest corner of the property; the Oceanside Water Pollution Control Plant (Southwest Sewage Treatment) on a joint-use site with the Zoo just south of Park Road; the Recreation Center for the Handicapped south of Zoo Road; Harding Park Golf Course and Lake Merced to the south; Golden Gate National Recreation Area to the west; and residential/commercial development to the north and east of the Zoo. The proposed infrastructure project would not disrupt or divide the physical arrangement of any residential or commercial development because it would be entirely within the existing Zoo property. The proposed project would not alter or change the recreational use of the site. The Zoo would remain open to the public during construction of the proposed project.

The project would not have a substantial impact upon the existing character of the vicinity, nor would it substantially degrade or obstruct any scenic views or vistas observed from a public area or have a demonstrable negative aesthetic effect because the utilities would be

[illegible]

primarily below-ground and any above-ground facilities, such as pumps, would be enclosed. The construction site would be maintained litter-free (see Mitigation Measure Number 2).

Because the project would be primarily within the Zoo property boundary (with the exception of a 500 foot segment of the sewer system along Sloat Blvd.) no housing would be displaced by the proposed infrastructure project. Construction would not require relocation of businesses or residences. The proposed project would not introduce increased concentrations of population to the site. About ten to fifteen construction workers per shift would be on the site at any one time during construction of the project.

The proposed improvements would not cause long-term changes in traffic or parking patterns. Temporary disruption to traffic along Sloat Blvd. between 47th and Great Highway would take place during construction of the 500 foot sewer connector. Temporary construction staging and off-street parking for construction workers would be provided at the Fleishhacker Pool parking area on Zoo property with access off Zoo Road and Skyline Boulevard (see Mitigation Measure Number 3). In addition to construction worker vehicles, a flatbed truck and 1 or 2 pickup trucks, at most, would access the site during a peak construction day/week. The project site is served by public transit. Muni bus lines 18 and 23 serve the site, and the L Taraval rail line is in the project vicinity.

Construction work would be performed between the hours of 7:00 am and 5:00 pm in accordance with the City of San Francisco Noise Ordinance, Article 29 of the City Police Code, regarding construction noise. The proposed construction could generate noise that may be considered an annoyance to occupants of nearby properties. However, due to the temporary and intermittent nature of this impact, and the relatively high traffic noise levels along Sloat Boulevard and The Great Highway in the immediate area, construction noise impacts to nearby properties from the project would not be substantial.

Environmental noise is usually measured in A-weighted decibels (dBA). A decibel (dB) is a logarithmic unit of sound energy intensity. Sound waves, traveling outward from a source, exert a sound pressure level measured in dB. An A-weighted decibel (dBA) is a decibel corrected for the variation in frequency response of the typical human ear at commonly encountered noise levels. A typical noise descriptor is the energy-equivalent noise level (Leq). The Leq is the equivalent continuous sound level which has the same energy content as the varying sound level over the period monitored.

In accordance with Zoo environmental practices, noise monitoring took place in April 1994 during construction of the Feline Conservation Center near the Rhino Exhibit at the northern and southern fences, the southern fence line of the Zebra Exhibit, and at the Recreation Center for the Handicapped (RCH). Short-term spot monitoring showed noise levels varying from 64 to 70 dBA, Leq and maximum noise levels measuring from 79 to 83 dBA. Long-term monitoring (three 24-hour workdays and two weekend days) showed weekend "baseline" daytime peaks from 65 to 72 dBA, Leq.¹

During the week, while construction activity for the Feline Conservation Center took place, daily peaks ranged from 70 to 75 dBA. The selected "baseline" hourly noise level was 64 dBA. Noise plots indicated that construction work was performed between the hours of 7:00 am and 5:00 pm in accordance with the City's Noise Ordinance. Spot monitoring of construction equipment indicated that the equipment noise levels were in

¹ Environmental Science Associates, Inc. "Noise Monitoring of Feline Conservation Center Construction Activities", May 1994.

compliance with the City of San Francisco Noise Ordinance Article 29 of the City Police Code.

Grading operations resulted in increases of up to eleven dBA over a selected "baseline" hourly noise level of 64 dBA. Drilling operations resulted in increases of up to 14 dBA at the fenceline of the rhino exhibit. To the human ear, an increase of 10 dBA is generally perceived as a doubling of loudness. The Rhino and Zebra populations were likely subjected to noise levels at least twice as loud as they usually experience during the periods of grading and drilling at the construction site. Zoo keepers monitored animal behavior during this same period and no substantial effects to Rhino or Zebra populations were reported.

Extensive noise monitoring also took place during the construction of the Oceanside Water Pollution Control Plant on the corner of the site jointly used by the Zoo and the Clean Water Program. The monitoring revealed that some Zoo animals (birds, gorillas) were sensitive to impulsive noise during construction. This was particularly true during breeding seasons. The sensitivity of birds of prey, and other raptors in particular, has been documented by the San Francisco Zoological Society and substantiated in their literature review and monitoring of construction activities at the Zoo.² Examples of impulsive noise are jackhammers, drilling equipment, and truck back-up beepers. Effective mitigation measures included: temporarily relocating sensitive animals to an area within the Zoo away from the construction activity; placing a noise barrier (wall or berm) between the animal and the noise source; or habituating the animal to the noise over a several day period. The monitoring for the Oceanside Water Pollution Control Plant also revealed that some animals are not bothered by construction noise.³ A recent survey of Zoo keepers, conducted to provide information on the sensitivity of animals to construction, revealed that the existing Avian facilities would need to be relocated to protect birds from noise and visual disturbance during construction of the infrastructure project.⁴ Further, according to the Zoological Society, the endangered status of some birds (bald eagles, peregrine falcons) and the sensitivity during breeding places added responsibilities on the Zoo to protect these species and meet US Fish and Wildlife Service and California Fish and Game endangered species propagation goals.

Noise from construction activities (trenching, drilling and backhoe work) could cause noise increases over "baseline", similar to those experienced during construction of The Feline Conservation Center. No significant adverse impacts from that construction activity were observed. No pile-driving or blasting would take place. In order to assure that this impact remains at a less than significant level, the project sponsor has committed to noise mitigation and monitoring (see Mitigation Measure Number 4).

The Bay Area Air Quality Management District (BAAQMD) has established thresholds for projects requiring its review for potential air quality impacts. These thresholds are based on the minimum size projects which the BAAQMD considers capable of producing air quality problems.

The proposed project would not violate any ambient air quality standard. It would not be expected to emit significant amounts of primary pollutants nor would it be expected to

² Letter from John Aikin, Director of Avian Conservation Program, dated March 21, 1987, regarding environmental concerns related to the Southwest Water Pollution Control Plant.

³ Memo from N. Schofield, Zoo Curator, dated January 10, 1993, to M. Jurosek, Zoo Assistant Director, "Clean Water Project and Effects on San Francisco Zoo Animals".

⁴ Associated BioTechnology, "Mitigation Procedures to Protect Zoo Animals During Infrastructure Construction", February 17, 1994.

affect compliance with primary air pollutant standards because it would involve minimal combustion activity in equipment and trucks and would not generate significant traffic.

Site preparation and construction activity would temporarily raise dust levels in the local area. To ensure that windblown dust associated with site preparation and trenching activities do not result in significant contributions to local airborne particulate matter, or possibly result in adverse effects on sensitive animals in the Zoo, a dust suppression mitigation measure is included in the project requiring site watering and the covering of stockpiled and transported materials (see Mitigation Measure 5).

The Zoological Gardens would continue to be served by existing public utilities and services (PG&E and the City Fire, Water and Police Departments) and existing communications facilities. Replacement of the infrastructure would not require substantial expansion of any of these services or facilities.

The project site is an existing Zoological Garden exhibiting 183 species of mammals, reptiles, amphibians and birds (713 specimens) and 64 species of insects and arthropods (6000 specimens). The endangered or threatened species being exhibited at the Zoo numbered 26 as of November 1, 1994. While there may be some listed endangered plant species in or near Lake Merced, they would not be affected by Zoo construction.

The Zoo is bounded on the west by the Great Highway, along which vegetation is relatively sparse. The sandy dunes on either side of the Highway sustain mainly ice plants. Along the eastern boundary of the Zoo (Skyline Boulevard) there is comparatively more vegetation. Eucalyptus is the predominant type of tree in this area, with hardy bushes such as Scotch broom growing under the trees. Ice plants are in evidence in this area as well. Lake Merced is to the east of Skyline Boulevard and its vegetation is maintained by the Recreation and Park Department. A major portion of the Lake Merced and Harding Park area is covered in lawn and much of this is used for a golf course. By the Lake itself, waterfowl and fresh water marsh vegetation exist. To the north and northeast of the Zoo is a primarily residential neighborhood with residential landscaping. Shorebirds, such as Gulls, are in evidence.

With mitigation, the proposed project would not adversely affect any rare or endangered species or habitats and would not interfere with any resident or migratory species. The proposed project includes mitigation measures and monitoring for the protection of Zoo animals from construction related noise and dust (see Mitigation Measure 4).

The infrastructure project would be constructed along existing paved pathways or roads within the Zoo site. Disturbance to natural vegetation would be minimal. Disturbance to landscaped areas during construction would be mitigated by landscape replacement (see Mitigation Measure Number 6).

The Zoo site is underlain by dune sands, as is most of the western part of the City. The Zoo is within a special geologic study area due to potential earthquake-induced ground failure hazards. Numerous historically-active faults run near the Zoo: the San Andreas, Seal Cove-San Gregorio, Hayward, and Calaveras faults. These are approximately three, five, 18, and 29 miles from the Zoo site respectively. Several inactive faults are also located near the site. The San Bruno fault, which is the closest one, parallels the San Bruno mountains and passes through Lake Merced. The Zoo is in an area of "probable liquefaction potential" a term which characterizes the Ocean Beach area and areas east of the beach.

Preliminary engineering and geotechnical analysis for the project has determined that the project is feasible; however, specific geotechnical recommendations would be part of the next phase of the engineering and design for the project. A final geotechnical report would be prepared by a California-licensed soils engineer. Excavation and construction would conform to the recommendations of that report (see Mitigation Measure 7)

The San Francisco Zoo is located within the Sunset portion of the Westside Groundwater Basin. In 1992, the USGS published reports on groundwater inflow/recharge and discharge for the Westside Basin, which includes the Sunset and Lake Merced areas. The information and conclusions regarding groundwater use and impacts are taken from a Technical Memorandum prepared by AGS, Inc., which in part drew upon information contained in the 1992 USGS report.⁵ The main aquifer system in the Westside Basin is multi-layered and consists of two water-bearing formations.

- The shallower formation consists of Upper Colma Formation sediments, is unconfined and is the source of pumped groundwater for a number of wells in the Westside Basin. Excessive pumpage from this shallow aquifer has altered levels in Lake Merced, which is in essence a surface expression of the aquifer.
- The deeper formation consists of Lower Colma and Merced Formations, is confined and is the larger of the two aquifers. Recharge to the Sunset portion of the Westside Basin between Golden Gate Park and the Zoo is estimated to be 2,700 acre-feet per year, indicating that this amount is available for future use.

Data exists from existing well geophysical logs which indicates that the shallow and deep aquifer systems beneath the Zoo are hydraulically separated by a confining silty clay aquitard. This aquitard also serves to isolate the deeper fresh water aquifer from salt water where the aquifer underlies or is adjacent to the Pacific Ocean and it prevents salt water intrusion from becoming an issue at the planned Zoo replacement wells.

The existing Zoo groundwater wells draw from both of the two aquifers. Groundwater use in the Zoo currently accounts for about one-third of the Zoo's total water use; the remainder of the water used is potable Hetch Hetchy water purchased from the City. Current average annual groundwater pumpage at the Zoo is estimated at about 250 Acre-feet per year (AF/yr).

The proposed Zoo replacement wells would tap only the Lower Colma and Merced Formations and would not have a noticeable impact on the water level of Lake Merced.

The long-term goal of the Zoo is to minimize the use of potable water and maximize the use of available groundwater from the deep aquifer and, if and when available, from reclaimed water. Groundwater will be the Zoo's primary water supply source until reclaimed water may become available, which could replace some of the groundwater use. Prior to reclaimed water availability, annual groundwater pumpage with the infrastructure replacement would be about 525 AF/yr. If and when reclaimed water becomes available, groundwater use could be reduced to about 280 AF/yr., approximately 12 percent more than existing use, but still well below the available amount of 2,700 AF/yr. The net effect is that the Zoo replacement wells and anticipated Zoo groundwater pumpage would have a negligible impact on the groundwater resources in the Westside Groundwater Basin.

⁵ Technical Memo from AGS, Inc. to Fred Neal at Kennedy/Jenks Consultants, dated September 16, 1994, "Zoo Water Resource Feasibility Analysis and Well Destruction Issues".

Existing and future water use, in gallons per day and AF/yr. are presented in the table below.

Water Use for the Zoo (in gallons per day and acre-feet/year)

Existing System (1994):

Potable Water Use	450,000 gpd (actual meter readings)	504 AF/yr
Groundwater Use	216,000 gpd (6 hours per day @ 600 gpm)	242 AF/yr
Reclaimed Water Use	0 gpd	0 AF/yr
Existing System Total	666,000 gpd	746 AF/yr

Replaced System:

Potable Water Use	34,000 gpd	38 AF/yr
Groundwater Use	469,000 gpd*	525 AF/yr*
Replaced System Total	503,000 gpd	563 AF/yr

*NOTE: The City is currently pursuing a Reclaimed Water Master Plan, which would provide reclaimed wastewater for irrigation and other purposes. If that Plan is approved and developed, the Zoo could make use of about 220,000 gpd (246 AF/yr) of reclaimed water, which would reduce groundwater demand to 249,000 gpd (280 AF/yr). Based upon DPW's current schedule, reclaimed water could be available no sooner than year 2000. As the above data indicates, the overall water use with the proposed utility replacement project would decrease by about 163,000 gpd for a typical operating day and 183 AF/yr primarily as a result of repaired/replaced system components that are leaking or are inefficient. Available groundwater would be used to meet irrigation and Zoo exhibit demands currently served with Hetch Hetchy potable water and reclaimed water, if and when available, would be used for landscape irrigation.

It is not anticipated that there will be any significant increase in consumption of fuel, water, or energy resources. The project would be constructed to conform with the energy requirements of Title 24 of the California Code of Regulations. It would not encourage activities that would result in the wasteful use of energy or have a substantial effect on a natural resource. The project would be designed to correct existing leaking water supply systems and improve efficiency of the utility system (see Mitigation Measure Number 8).

The project would not create a health hazard or be affected by hazardous uses. Asbestos-containing materials, such as pipe insulation, involved in replacement would be removed in accordance with Title 8, Section 5208 of the California Administrative code. The project sponsor would ensure that project compliance with the City's Emergency Response Plan is included in the project plans and specifications.

The history of the San Francisco Zoo shows that it was founded in 1929 as part of a larger recreation complex dating from 1922, when the City acquired 60 acres from the Spring Valley Water Company. Fleishhacker Playfield and Zoological Gardens, named for Herbert Fleishhacker, then President of the Park Commission, opened in 1924. Only 37 acres were developed initially. The Zoo began with a small collection of animals that came

from Golden Gate Park, where wild and domesticated animals had been exhibited since 1889.

In 1935, 68 additional acres adjoining the existing Zoo were purchased, and on this land WPA labor constructed the bulk of the buildings. Construction of the Zoological Gardens continued from the late 1930's into the next decade. Features of the original Zoo plan which still exist are the Lion House, the Pachyderm House, Monkey Island, the Bear Grottos and the Aviary.

A building of historic importance, located just inside the main entry to the Zoo, is the Delia Fleishhacker Memorial Building, or the Mother's Building, as it is more commonly called. The building was constructed in 1925 to provide a resting place for mothers and children. Funds for the building were donated by Herbert Fleishhacker in honor of his mother. The stuccoed tile-roofed building was built in the Italian Renaissance style and minor alterations have not significantly altered its original design. Interior murals and exterior mosaics are the work of WPA artists during the Great Depression.

The Mother's Building was used continuously until the 1960's when the major portion was closed. From 1973-1978, the building served as a visitor center. It currently serves as a gift shop selling Zoo-related merchandise to Zoo visitors.

The building was listed on the National Register of Historic Places December 31, 1979. The San Francisco Recreation and Park Department applied for state funds to restore the building, and the restoration project has been granted a Categorical Exemption from CEQA by the San Francisco Department of City Planning (September 29, 1988). State Funds have not been granted.

The proposed project would not affect the Mother's Building. The project would include little excavation and would be primarily concentrated along existing pathways. There are no known archaeological sites within the immediate site area.⁶ Considering these factors, it would be unlikely that archaeological resources would be destroyed or disrupted by the project.

Required approvals and permits for local and state agencies follow:

⁶ Southwest Water Pollution Control Plant Final EIR, File #EE 76.389, certified August 23, 1979, p.83.

AgencyAuthority**Local Agencies**

City Planning Commission

Approval of Initial Study/Negative Declaration in accordance with CEQA and the S.F. Admin. Code.

San Francisco Water Department

Approval of plans and specifications, and approval to connect to City's water supply

Recreation and Park Commission

Approval of plans and specifications

San Francisco Bureau of Light, Heating and Power

Approval to connect to PG& E power grid

San Francisco Public Health Department

Approval of plans and specifications

S.F. Fire Department

Approval of plans and specifications

DPW, Bureau of Building Inspection
Board of Supervisors and Mayor's Office

Approval of plans and specifications

Approval of project and Prop M findings and authorization of bond sales and expenditure of bond funds

State Approvals

Regional Water Quality Board

Issuance of a revised NPDES Permit and statement of project conformity with appropriate state and federal plans and regulations
Approval of plans and specifications for irrigation system for reclaimed water use

California Coastal Commission

Review of existing Zoo /City permit for compatibility with Commission guidelines in accordance with Section 30412 of the California Coastal Act of 1976

While local concerns or other planning considerations may be grounds for modification or denial of the proposal, in the independent judgement of the Department of City Planning, there is no substantial evidence that the project could have a significant effect on the environment.

MITIGATION MEASURES

As of January 1, 1989, state law requires that a reporting or monitoring program be adopted for mitigation measures that are included in the approval of any project that would

otherwise have significant environmental effects. Mitigation would include monitoring to verify its effectiveness and reporting to the City and to the Zoo Task Force on a monthly basis. Construction would be phased to minimize disruption during peak visitor times.

The following mitigation measures have been agreed to by the sponsor as a part of the project.

1. The existing Avian Center will be relocated to mitigate for potential construction related impacts from the infrastructure project. The Avian Conservation Center would be relocated within the Zoo, west of Zoo Road and adjacent to the National Guard Armory.
2. The Contractor will be responsible for maintaining the site in a clean and litter-free condition. Maintenance would include removal of all refuse blown or deposited on the site. All loose debris, building material waste and other refuse would be appropriately disposed of. Paths and paved areas would be kept clean and free of dirt or other material resulting from construction activity. DPW will require the project contractor to screen (with a six-foot high fence) storage areas during construction in order to minimize views of construction-related materials by Zoo visitors.
3. Construction workers will park in the Fleishhacker Pool site which would also serve as the staging area for the project.
4. DPW will require the contractor to carry out construction activities in a manner such that the noise criteria specified in the City of San Francisco Noise Ordinance Section 2907 (regarding Construction Noise) would not be exceeded. The contractor will use appropriate construction methods and equipment and will install acoustical barriers as necessary. Jackhammers will be provided with intake and exhaust mufflers and, if necessary, acoustical attenuating shields or shrouds recommended by the manufacturer and approved by the Director of Public Works as the best available means of accomplishing maximum noise level reduction. The contractor will submit the plans for mitigation of noise impacts to the construction manager for approval. Periodic measurement of noise levels will be made by the construction manager who will be provided contractual authority to require modification or stoppage of construction activity which exceeds noise criteria. The contractor will use the best practicable noise mufflers on all construction equipment. Construction will progress in such a way as to habituate Zoo animals to construction noise and avoid breeding seasons. Whenever any unusually noisy construction activity which might exceed the noise criteria is anticipated, Zoo staff will be notified in advance of activity. Sound levels at sensitive sites in the Zoo will be monitored during potentially noisy operations nearby. The responses of sensitive animals will be monitored and any behavioral changes that may be related to construction noise will be noted and construction would be halted until animals can be relocated to another area within the Zoo or habituated.
5. The project sponsor will require that the general contractor sprinkle unpaved construction areas with water at least twice per day to reduce dust generation by about 50 percent; cover stockpiles of soil, sand, and other materials; cover trucks hauling debris, soil, sand or other material; and sweep streets surrounding construction sites at least once per day to reduce particulate emissions. Ordinance 175-91, passed by the Board of Supervisors on May 6, 1991, requires that non-potable water be used for dust control activities. The project sponsor will require the project contractor(s) to maintain and operate construction equipment so as to minimize exhaust emissions of particulates and other pollutants, by such means as a prohibition on idling motors when equipment is not in use or when trucks are waiting in queues, and implementation of specific maintenance programs to reduce emissions for equipment that would be in frequent use for much of the construction period.

6. Any disruption to vegetation will be corrected by replanting.
7. The project sponsor will retain a qualified geotechnical engineer to review the final grading plans prior to construction; observe the required compaction of soils in the utility corridors; and observe the installation of drains.
8. If any utility service interruption should occur in the project area as a result of construction, the DPW Construction Manager will verify that the utility involved was notifying its affected customers and will provide referrals to appropriate utility personnel in response to inquiries.

MANDATORY FINDINGS OF SIGNIFICANCE

As part of the City's Waste Water Master Plan, the following projects have been constructed in the immediate vicinity of the Zoo: the Great Highway Storage and Transport, Westside Pump Station Projects, Lake Merced Transport Tunnel, Oceanside Water Pollution Control Plant and the Ocean Outfall. The City is now considering two more projects relating to the Waste Water Master Plan, in the vicinity of the Zoo: the Bayside Discharge Alternatives and the Tertiary Treatment Facility. These two planned projects will have a separate environmental review. In addition to the Waste Water Projects, an individual project within the Zoo that has been constructed is the Feline Conservation Center. Other Zoo projects that are planned for construction include: the Mammal Conservation Center on the Joint-use site with the Oceanside Water Pollution Control Plant, the Leopards of Asia Exhibit and the Orangutan Forest Exhibit. These Zoo projects have received environmental review and approval by the City. The cumulative effects of these projects have been considered as part of the on-going planning and coordination process between the Zoological Society, the Department of Public Works, the Recreation and Park Department and a Joint-Use Task Force made up of neighborhood representatives and Zoo staff. The mitigation measures and mitigation monitoring program developed and applied to the projects already constructed (particularly Lake Merced Transport and Oceanside Water Pollution Control Plant and the Feline Conservation Center) have been effective in minimizing potential impacts to Zoo animals and visitors.

These same mitigation measures are included as part of the proposed project and are specifically designed to mitigate both project-specific impacts and potential cumulative impacts to the environment.

File No: 94.366E Title: S.F. Zoo Infrastructure Replacement Project
 Street Address: 1 Zoo Road Assessor's Block/Lot: 7281/6,7
 Initial Study Prepared By: The Duffey Company

A. <u>COMPATIBILITY WITH EXISTING ZONING AND PLANS</u>		Not Applicable	Discussed	
1)	Discuss any variances, special authorizations, or changes proposed to the City Planning Code or Zoning Map, if applicable.	<u> x </u>	<u> </u>	
* 2)	Discuss any conflicts with any adopted environmental plans and goals of the City or Region, if applicable.	<u> </u>	<u> x </u>	
B. <u>ENVIRONMENTAL EFFECTS</u>				
1)	<u>Land Use</u> . Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
* (a)	Disrupt or divide the physical arrangement of an established community?	<u> </u>	<u> x </u>	<u> x </u>
* (b)	Have any substantial impact upon the existing character of the vicinity?	<u> </u>	<u> x </u>	<u> </u>
2)	<u>Visual Quality</u> . Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
* (a)	Have a substantial, demonstrable negative aesthetic effect?	<u> </u>	<u> x </u>	<u> x </u>
(b)	Substantially degrade or obstruct any scenic view or vista now observed from public areas?	<u> </u>	<u> x </u>	<u> x </u>
(c)	Generate obtrusive light or glare substantially impacting other properties?	<u> </u>	<u> x </u>	<u> </u>
3)	<u>Population</u> . Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
* (a)	Induce substantial growth or concentration of population?	<u> </u>	<u> x </u>	<u> x </u>
* (b)	Displace a large number of people (involving either housing or employment)?	<u> </u>	<u> x </u>	<u> x </u>
(c)	Create a substantial demand for additional housing in San Francisco, or substantially reduce the housing supply?		<u> x </u>	

*Derived from State EIR Guidelines, Appendix G, normally significant effect.

4)	<u>Transportation/Circulation</u>	Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a)	Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system?	_____	<u> x </u>	<u> x </u>
	(b)	Interfere with existing transportation systems, causing substantial alterations to circulation patterns or major traffic hazards?	_____	<u> x </u>	_____
	(c)	Cause a substantial increase in transit demand which cannot be accommodated by existing or proposed transit capacity?	_____	<u> x </u>	_____
	(d)	Cause a substantial increase in parking demand which cannot be accommodated by existing parking facilities?	_____	<u> x </u>	<u> x </u>
5)	<u>Noise</u>	Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a)	Increase substantially the ambient noise levels for adjoining areas?	_____	<u> x </u>	<u> x </u>
	(b)	Violate Title 24 Noise Insulation Standards, if applicable?	_____	<u> x </u>	_____
	(c)	Be substantially impacted by existing noise levels?	_____	<u> x </u>	_____
6)	<u>Air Quality/Climate</u>	Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a)	Violate any ambient air quality standard or contribute substantially to an existing or projected air quality violation?	_____	<u> x </u>	<u> x </u>
*	(b)	Expose sensitive receptors to substantial pollutant concentrations?	_____	<u> x </u>	<u> x </u>
	(c)	Permeate its vicinity with objectionable odors?	_____	<u> x </u>	_____
	(d)	Alter wind, moisture or temperature (including sun shading effects) so as to substantially affect public areas, or change the climate either in the community or region?	_____	<u> x </u>	_____

*Derived from State EIR Guidelines, Appendix G, normally significant effect.

7)	<u>Utilities/Public Services.</u> Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a) Breach published national, state or local standards relating to solid waste or litter control?	_____	<u>x</u>	_____
*	(b) Extend a sewer trunk line with capacity to serve new development?	_____	<u>x</u>	_____
	(c) Substantially increase demand for schools, recreation or other public facilities?	_____	<u>x</u>	_____
	(d) Require major expansion of power, water, or communications facilities?	_____	<u>x</u>	<u>x</u>
8)	<u>Biology.</u> Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a) Substantially affect a rare or endangered species of animal or plant or the habitat of the species?	_____	<u>x</u>	<u>x</u>
*	(b) Substantially diminish habitat for fish, wildlife or plants, or interfere substantially with the movement of any resident or migratory fish or wildlife species?	_____	<u>x</u>	_____
	(c) Require removal of substantial numbers of mature, scenic trees?	_____	<u>x</u>	<u>x</u>
9)	<u>Geology/Topography.</u> Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a) Expose people or structures to major geologic hazards (slides, subsidence, erosion and liquefaction)?	_____	<u>x</u>	_____
	(b) Change substantially the topography or any unique geologic or physical features of the site?	_____	<u>x</u>	_____
10)	<u>Water.</u> Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
*	(a) Substantially degrade water quality, or contaminate a public water supply?	_____	<u>x</u>	_____
*	(b) Substantially degrade or deplete ground-water resources, or interfere substantially with ground water recharge?	_____	<u>x</u>	<u>x</u>
*	(c) Cause substantial flooding, erosion or siltation?	_____	<u>x</u>	_____

*Derived from State EIR Guidelines, Appendix G, normally significant effect.

11) <u>Energy/Natural Resources</u> . Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
* (a) Encourage activities which result in the use of large amounts of fuel, water, or energy, or use these in a wasteful manner?	_____	<u>x</u>	<u>x</u>
(b) Have a substantial effect on the potential use, extraction, or depletion of a natural resource?	_____	<u>x</u>	_____
12) <u>Hazards</u> . Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
* (a) Create a potential public health hazard or involve the use, production or disposal of materials which pose a hazard to people or animal or plant populations in the area affected?	_____	<u>x</u>	_____
* (b) Interfere with emergency response plans or emergency evacuation plans?	_____	<u>x</u>	_____
* (c) Create a potentially substantial fire hazard?	_____	<u>x</u>	_____
13) <u>Cultural</u> . Could the project:	<u>Yes</u>	<u>No</u>	<u>Discussed</u>
* (a) Disrupt or adversely affect a prehistoric or historic archaeological site or a property of historic or cultural significance to a community or ethnic or social group; or a paleontological site except as a part of a scientific study?	_____	<u>x</u>	<u>x</u>
(b) Conflict with established recreational, educational, religious or scientific uses of the area?	_____	<u>x</u>	<u>x</u>
(c) Conflict with the preservation of buildings subject to the provisions of Article 10 or Article 11 of the City Planning Code?	_____	<u>x</u>	_____

*Derived from State EIR Guidelines, Appendix G, normally significant effect.

C. <u>OTHER</u>		<u>Yes</u>	<u>No</u>	<u>Discussed</u>	
Require approval and/or permits from City Departments other than Department of City Planning or Bureau of Building Inspection, or from Regional, State or Federal Agencies?		<u> x </u>	<u> </u>	<u> x </u>	
D. <u>MITIGATION MEASURES</u>		<u>Yes</u>	<u>No</u>	<u>N/A</u>	<u>Discussed</u>
1)	Could the project have significant effects if mitigation measures are not included in the project?	<u> x </u>	<u> </u>	<u> </u>	<u> x </u>
2)	Are all mitigation measures necessary to eliminate significant effects included in the project?	<u> x </u>	<u> </u>	<u> </u>	<u> x </u>
E. <u>MANDATORY FINDINGS OF SIGNIFICANCE</u>		<u>Yes</u>	<u>No</u>	<u>Discussed</u>	
* 1)	Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or pre-history?	<u> </u>	<u> x </u>	<u> </u>	
* 2)	Does the project have the potential to achieve short-term, to the disadvantage of long-term, environmental goals?	<u> </u>	<u> x </u>	<u> </u>	
* 3)	Does the project have possible environmental effects which are individually limited, but cumulatively considerable? (Analyze in the light of past projects, other current projects, and probable future projects.)	<u> </u>	<u> x </u>	<u> x </u>	
* 4)	Would the project cause substantial adverse effects on human beings, either directly or indirectly?	<u> </u>	<u> x </u>	<u> </u>	

*Derived from State EIR Guidelines, Appendix G, normally significant effect.

F. ON THE BASIS OF THIS INITIAL STUDY

_____ I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared by the Department of City Planning.

☒ I find that although the proposed project could have a significant effect on the environment, there WILL NOT be a significant effect in this case because the mitigation measures, numbers 1-8, in the discussion have been included as part of the proposed project. A
_____ NEGATIVE DECLARATION will be prepared.

_____ I find that the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

BARBARA W. SAHM
Environmental Review Officer

for

LUCIEN R. BLAZEJ
Director of Planning

DATE: November 16, 1994

APPENDIX B:

**TECHNICAL MEMORANDUM:
ZOO WATER RESOURCE FEASIBILITY ANALYSIS
AND WELL DESTRUCTION ISSUES**

1. Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the participants.

The study was conducted in a laboratory setting.

The participants were selected from a pool of volunteers.

The results of the study are presented in the following sections.

TECHNICAL MEMORANDUM

TO: Fred Neal/KJ
Karen Kubick/DPW

FROM: Michael King/AGS
Chad Nichols/AGS

DATE: September 16, 1994

SUBJECT: Zoo Water Resource Feasibility Analysis and Well Destruction Issues

COPIES: Marla Jurosek/Zoo
David Roberts/Portico

INTRODUCTION

The objective of this study is to address the feasibility of providing a reliable water supply from subsurface resources for the San Francisco Zoological Gardens (Zoo). This technical memorandum has been prepared in accordance with the guidelines established in the December 1993 Technical Memorandum No. 1 (Kennedy/Jenks - AGS, Inc.). The issue of a groundwater system is one of six existing and/or proposed utilities currently in the planning or conceptual stages.

Additional objectives of this evaluation were to develop a preliminary well system design, select desirable well locations, and define well destruction criteria for the existing wells.

Background

The Zoo's groundwater system was originally constructed in the 1930s and currently consists of two 220-foot-deep production wells (Wells No. 3 and 4) with a total combined pumping capacity of 1,250 gpm, at the approximate locations shown on Plates 1 and 9. The actual construction history of the wells is unknown. A typical cable-tool-drilled well like those at the Zoo consists of a 12-inch-diameter, knife-cut slotted mild steel well casing set in a 14- to 16-inch-diameter borehole. The annular space between the borehole and casing was usually left to fill in with native material or crushed rock. The slots in the casing were usually over the full length of the well casing.

The current condition of the wells is poor. The average life of a mild steel well casing is 30 to 40 years. In time, corrosion of the casing can result in the plugging of slots in the casing and the potential collapse of the casing. The existing wells must be replaced if current and future water supply requirements are to be achieved.

The Zoo currently supplies groundwater for irrigation and washdown uses. Groundwater use over the course of the Zoo 2000 project will be for landscape irrigation, animal exhibit pools and water features, and washdown.

Scope of Study

The main objectives of this groundwater resource study were met by performing the study tasks outlined below.

Task 1.	Characterize Groundwater Resource
Task 2.	Evaluate Environmental Issues
Task 3.	Develop Preliminary Well System Design

Task 1. Characterize Groundwater Resource: The characterization of groundwater resources within the confines of the Zoo involved the determination of the hydrostratigraphy of the Westside Groundwater Basin (Westside Basin), an evaluation of the groundwater budget for the basin, and determination of hydraulic properties of water-bearing sediments for the purpose of preliminary well system design.

Task 2. Evaluate Environmental Issues: Because the Zoo is situated adjacent to the Pacific Ocean, the potential of salt water intrusion must be considered. In addition, the Zoo is situated in close proximity to Lake Merced, a significant recreation resource emergency water supply for the City and County of San Francisco. Thus, the possibility of the Zoo replacement wells affecting Lake Merced was evaluated. Also, the planned Zoo replacement well field is located near a reported hydrocarbon remediation site at 2940 Sloat Boulevard and 47th Avenue.

Task 3. Develop Preliminary Well System Design: A preliminary well system design has been prepared that develops the required groundwater resources at the site, and that minimizes or eliminates potential environmental impacts. Preliminary groundwater supply design specifications included well siting, well specifications, and construction and testing parameters.

In addition, this study evaluated siting/construction schedule criteria for the new wells as well as destruction criteria for the existing wells.

CHARACTERIZATION OF GROUNDWATER RESOURCE

The groundwater resources in the vicinity of the Zoo were characterized to determine if an adequate long-term water supply exists. The goal was to develop a profile (model) of the water-bearing sediments at the Zoo site. The areal and vertical distribution of water-bearing sediments were established by use of available geophysical and borehole cutting logs of wells in the study area. Hydraulic properties of distinct water-bearing zones were then estimated from previous aquifer pumping tests performed in the study area. The production potential of the targeted water-bearing

zones was evaluated against water supply requirements. The magnitude of the groundwater resources in the vicinity of the Zoo was then evaluated, which was based on previous water balance studies by the U.S. Geological Survey.

Hydrostratigraphy

The Zoo is situated on the southern half of the Westside Basin northwest of Lake Merced, immediately north of the new Oceanside Water Pollution Control Plant (OWPCP), and just east of the Pacific Ocean. The basin, which extends north through Golden Gate Park and to the south to San Francisco Bay in San Mateo County, is essentially an elongated trough encompassing an area approximately two miles wide and over 11 miles long. The boundaries of the Westside Basin appear to be defined by bedrock uplands to the east in the San Francisco portion of the basin, and by faulting that parallels the foothills that flank Colma Creek in the San Mateo County portion of the basin to the south. The San Andreas fault forms the offshore western boundary (approximately three miles offshore) of the basin.

The main aquifer system in the Westside Basin is multi-layered and consists of the two unconsolidated water-bearing formations of the Colma and Merced Formations. The shallower aquifer system consists of unconfined local dune sand, and upper Colma Formation sediments. The deeper aquifer, which is composed of sediments of the Colma and Merced Formation, appears to be semi-confined and is locally confined by a regionally continuous aquitard. The subsurface contact between the Colma and Merced aquifers is unclear, but occurs at approximately 310 feet below ground surface (bgs) (OWPCP Well). Based on geophysical information, bedrock appears to be as deep as 1,600 feet below sea level in the vicinity of the Zoo (Plate 2).

Geophysical logs (E-logs) from wells drilled in the area present sufficient data, with relative confidence, that confining aquitards do exist and hydraulically separate both the upper Colma and deep Colma/Merced Formations. These silty clay units appear to be continuous within the proximity of the Zoo. Based on both E-logs and sampling data, the deeper confined aquifer can be subdivided into two water-producing horizons. A 50-foot clay unit that separates the aquifer exists between 265 and 310 feet bgs. Probable screen intervals for future wells should be approximately from 150 to 265 and 310 to 460 feet bgs (265 feet of total screen), as shown on Plate 3.

The shallow unconfined aquifer, partly within the Colma Formation, is the source of pumped groundwater for a number of wells in the Westside Basin. Excessive pumpage from the shallow aquifer has altered levels in Lake Merced, which is in essence a surface expression of the aquifer.

The Colma and Merced Formation aquifers are the primary sources of groundwater for the Zoo and for the City of Daly City and a number of commercial and industrial facility wells in the study area. About seven existing water wells are located in the Sunset and Lake Merced portions of the Westside Basin, which includes the two existing Zoo wells. About 43 existing water supply wells are presently operating along Colma Creek south of the Zoo.

Groundwater Budget (Yield)

The USGS has developed groundwater budgets for the study area. The results of their evaluation are summarized as follows. Recharge to the Sunset portion of the Westside Basin between Golden Gate Park and the Zoo is estimated to be 2,700 acre-ft/year. Currently no groundwater is being pumped from the Sunset portion of the Westside Basin, which indicates that up to 2,700 acre-feet/year of groundwater is available for future development.

Groundwater recharge to the Lake Merced area is estimated to be about 1,700 acre-feet/year over an area of 2,600 acres. The Lake Merced portion of the Westside Basin is reported to be in an overdraft situation due to groundwater pumping from wells immediately adjacent to and south of Lake Merced.

The Zoo replacement well field is hydraulically connected to the Sunset portion of the Westside Basin. Some portion of the 2,700 acre-feet/year of recharge groundwater to the Sunset portion of the Westside Basin is available to the Zoo wells. This theory is supported by the observed pumping levels of the existing Zoo wells, which indicate no significant decrease in groundwater levels in their vicinity over the life of the wells.

The average annual pumpage for the two Zoo replacement wells is anticipated to be about 500 to 600 acre-feet/year. This quantity will be reduced significantly in the future when reclaimed water is available for irrigation. The net effect is that the Zoo replacement wells will have a negligible impact on groundwater resources in the study area beyond existing pumpage quantities.

ENVIRONMENTAL ISSUES

Environmental issues which the new wells will be designed to accommodate include salt water intrusion, the hydraulics of the Lake Merced area, and groundwater contamination. These issues are evaluated below. No other potential environmental hazards have been identified that may impact future water production from the Zoo's property.

Salt Water Intrusion

Available geological data and computer modeling analyses support the fact that the Colma and Merced aquifers increase significantly in depth and thickness in an offshore direction, which most likely extend to and possibly beyond the San Andreas Fault. The fresh/salt water interface is most likely at considerable depth in an offshore direction. Salt water intrusion has only been observed in the shallow dune sand deposits immediately adjacent to the Pacific Ocean shoreline in dewatering wells designed to overdraft the shallow aquifer system. The deeper production wells are all completed in the confined aquifer. The ability of the confining aquitards to isolate the deeper fresh water from salt water, combined with the localized drawdown of the water table near production

wells and the magnitude of the aquifer system, support the theory that salt water intrusion is not anticipated to be an issue at planned Zoo pumping rates.

Hydraulics of Lake Merced

Water levels in Lake Merced represent the local shallow aquifer groundwater table. Lateral groundwater gradients in the vicinity of Lake Merced are primarily from east to west, so Lake Merced is recharged by the shallow aquifer along its eastern boundary and discharges to the shallow aquifer along its western boundary (Haley & Aldrich, Inc., 1991). This hydraulic situation is illustrated on Plate 3. Groundwater extractions in the Lake Merced portion of the Westside Basin over the last 10 to 15 years have resulted in a general lowering of the level of Lake Merced. Average annual decline in Lake Merced levels was between 0.06 and 0.40 feet/year since 1978.

The USGS developed a two-dimensional groundwater computer model of the Lake Merced area. The USGS specifically modeled the pump test of the OWPCP well over a 20-year period to determine effects on the shallow aquifer and Lake Merced. Their analysis indicated that after 10 days of pumping, 77 percent of the water produced was coming from storage, 12 percent from leakage from bottom layer aquifers, and 11 percent from leakage from the upper layer aquifers (Yates, et. al, 1990). It was concluded that storage response in the overall aquifer system was very slow and that the full effects of increased pumping from the deeper aquifer system would not become apparent for several years (Yates, et.al, 1990).

Haley & Aldrich, Inc. also developed a groundwater computer model of the Lake Merced area to evaluate the effects of the Richmond Transport Tunnel shallow dewatering wells on water levels in Lake Merced. The foundation for this model was the USGS groundwater model of the Lake Merced area. The results of the model also supported the conclusions of the previously discussed USGS model that the existing Zoo wells have no distinguishable effect on water levels in Lake Merced.

The planned Zoo replacement wells will be completed to produce water from the deeper aquifer system. As planned, the wells will be required to provide water to the Zoo. The demand for groundwater at the Zoo will eventually be reduced as reclaimed water becomes available. It is also apparent from the USGS evaluation of the deeper aquifer system that the replacement Zoo wells will not have a noticeable impact on the water level of Lake Merced. It can be concluded that the effect of the Zoo replacement wells on Lake Merced is not an issue based on their planned operating scenario.

Groundwater Contamination

A former Chevron service station was situated at 2940 Sloat Boulevard at 47th Avenue, immediately north of the Zoo and east of the Great Highway. In 1985, Chevron announced that approximately 2,000 gallons of unleaded gasoline had been lost, based on their fuel inventory. EMCON was retained to perform the subsurface soil and groundwater investigation.

EMCON installed 17 groundwater monitoring wells (C-1 through C-17), and two extraction wells (R-1 and R-2) (see Plate 4). Groundwater flow calculations reported movement in the shallow aquifer in a south-southwest direction, at a rate of 0.5 feet/day and an average gradient of 6×10^{-3} . By 1989, 3,000 gallons of fuel had been reported recovered from the shallow aquifer. Apparently, more fuel was lost than originally reported in 1985. There is sufficient evidence that an aquitard exists between the shallow unconfined and deeper confined aquifers and, based on available data, there appears to be virtually no potential for downward migration. Neither of the two consultants for Chevron explored deeper than 61 feet bgs. In this area, the shallow aquifer extends to approximately 140 feet in depth. Well correlations show a well-developed aquitard over 20 to 40 feet thick that should effectively seal the deeper confined aquifer from contaminant migration.

Based on the Quarterly Monitoring Report submitted by Pacific Environmental Group (PEG) in March 1994, groundwater occurs at 13 feet bgs or 5 feet above mean sea level (MSL). The flow direction of the groundwater is southwestward toward the northwest corner of the Zoo property and directly in line with the present Zoo wells. Estimates indicate that it would require a minimum of one year of uncontrolled migration in the shallow aquifer for the plume to reach the Zoo property (based on 0.5 ft/day). Chevron and their consultant believe that the contaminant plume, which has impacted only the shallow aquifer, has been prevented from migrating offsite.

With the cessation of operations at the Chevron facility, and the combined removal of soil vapor and impacted groundwater, PEG is recommending closure of the site. There has been a significant reduction in the overall concentrations and, if this trend continues, regulatory approval for PEG's request for closure may likely occur.

If there was migration of petroleum compounds onto the Zoo property, the time frame (nine years) has likely resulted in the biodegradation of much of the remaining petroleum compounds. EMCON has recommended a combined pumping rate of 150 to 200 gpm from both extraction wells R-1 and R-2, which could reverse flow back to the Chevron property.

It is our opinion that there is very little, if any, potential impact to the deeper confined aquifer resulting from the Chevron plume. Completion of the new Zoo replacement wells in the deeper aquifer (below 150 feet bgs) should yield unaffected groundwater. If drill cuttings from near-surface soils have a petroleum odor, they can be spread in a lined, bermed area and allowed to aerate for a period of time. Before replacement or disposal of the aerated soil, composite soil sampling would be advisable. The proposed well design will case through the potentially affected shallow aquifer to assure that cross-contamination does not occur.

PRELIMINARY WELL DESIGN

The preliminary well system design is focused on the drilling and construction of the replacement production wells. The preliminary well pump system cannot be prepared until the production wells have been constructed, tested, and their actual capacity has been defined. The water storage

reservoir is not evaluated in this study. The preparation of the preliminary well system design for the Zoo replacement wells involved well and siting analysis and preparation of well design specifications, which are discussed below.

Well Siting and Construction Schedule

The Zoo 2000 project design team has selected the two-production-well alternative, which consists of two production wells each capable of pumping 1,250 gpm. Only one well will be pumped at a time, while the other will serve as a backup system.

The site selection criteria for the two replacement Zoo wells included the following issues:

- Conflict with current exhibits and proposed Zoo 2000 Master Plan
- Distance from Lake Merced
- Drill rig access and available work area
- Distance from sewer and waste disposal lines
- Proximity to and feasibility for connection to the Zoo water system
- Proximity to an adequate electric supply
- Environmental constraints such as underground storage tanks (USTs)

The proposed locations of replacement Well No. 5 and Well No. 6 are shown on Plates 5A/5B and 6A/6B, respectively. These locations represent satisfactory locations in terms of current and future exhibits and distance from Lake Merced.

At present, there is adequate space available for the drilling and construction of the replacement wells. The drilling operation requires an area of 100 x 200 feet for drilling equipment and an additional 100 x 200 feet to store drill cuttings and supplies. Drilling operations will have to be designed to significantly reduce noise, and will have to be scheduled to avoid breeding periods of the animals.

The proposed well locations are not within 50 feet of existing sewer facilities. Future facilities must be designed to ensure that no sewer line is closer than 50 feet to the replacement wells.

The proposed location of Well No. 6 is approximately 1,100 feet south of Well No. 5 and the existing reservoir, along the western fence of the zoo property. These distances to the existing reservoir are acceptable for purposes of the well system design. The drill site will ultimately be determined by overhead obstructions and available space (Plates 6A and 6B). The well location will be near a gated access west of the future stork and rhinoceros facilities. The open area of the former Fleishacker Pool will serve as an excellent storage and staging area during both well construction phases.

The distance of the planned replacement wells from electric service connections is a design cost issue. The well pumps will, in general, require a 460-volt, 150-amp service connection panel. This size of service panel does not require special transformer facilities.

AGS met with a representative of Layne-Western Drilling on August 4, 1994, to discuss the logistics of drilling Wells No. 5 and No. 6. Layne-Western has been the drilling subcontractor on a number of wells installed in the area (i.e. OWPCP well, Olympic Golf Course wells, and Sunset Playground WSP1 well). Based on the site walk, a well can be installed in both proposed locations. The anticipated schedule of events is illustrated on Plate 7 and summarized below:

1. Initially, a "bucket rig" will drill the 36-inch-diameter hole to 60 feet bgs. This will take two days to drill and install 30-inch-diameter conductor casing (Appendix A, Photos 1-4).
2. A reverse-circulation drill rig will be towed in on a semi-tractor/trailer and positioned over the cased hole (Appendix A, Photos 2 and 5-8).
3. Actual drilling time for the 520-foot-deep pilot boring will be only two to three days. The hole will be left open with a high-viscosity drilling fluid for geophysical logging. A typical log suite will include spontaneous potential, gamma ray, and induction lateral log/conductivity to identify lithologies, water-bearing formations, and water quality (Appendix A, Photos 9-12).
4. Normally, production casing requires manufacturing, and delivery may take one or two weeks. The subcontractor should decide whether to leave the rig on-site or reposition to Well No. 6. (Appendix A, Photo 8).
5. After interpretation of the E-log, operations will cease until the casing and slotted screen arrive. The boring will likely collapse inward during the waiting period. The boring will be easily redrilled and reamed (widened) to a 28-inch diameter. Typical time required to install casing and build the well is 24 to 36 hours. The casing is welded and hung at a specified depth, and the well is bailed for 12 hours. Then gravel is tremied into place around the screened zone(s), and cement is tremied from the top of the gravel back to the surface.
6. After allowing 24 to 48 hours for the annular seal to set, two close-fitting surge blocks separated 10 to 20 feet by a perforated pipe will be placed near the top of the screen and 650 psi of air pressure will be sent through the perforated pipe. The turbulence of the air develops the gravel pack over time. This may take up to 24 hours to adequately purge the well of fine materials.
7. Pump testing will begin with a 12-hour step-test to determine the wells' maximum sustainable rate. Subsequently, the three-day pumping test will run continuously at 24 hours per day, for three consecutive days. We anticipate that over six million gallons of water will be generated throughout the duration of each pumping test. A 21,000-gallon Baker Tank will be delivered to the site to serve as a siltation trap before the pumped groundwater is allowed to be disposed of (Appendix A, Photos 13-16). The Department of Public Works Bureau of Environmental Regulations and Management (BERM) will require initial sampling before the pumped water is allowed to be disposed of in a drain. BERM normally charges a \$4.00

per "unit" fee to dispose of the water (a unit is defined as 100 ft³). The estimated disposal cost could exceed \$32,000 per well. AGS has contacted BERM and requested discharge permission and has proposed waiving the per-unit fee. Permission is pending.

8. The turbine/shaft pump will be ordered as per AGS' specifications from a supplier in the area. The pump's internal bowls and impellers do not present a problem, but building the pump motor may take a month or longer. It will require about 2.5 days to install the pump into the well (Appendix A, Photos 17-20).

In addition to the items discussed above, the following unresolved technical issues require immediate attention:

1. Plate 5A illustrates the configuration of the Well No. 5 drill site. For safety, removal or relocation of two overhead phone/electrical lines, as well as removal of the fence line directly behind the drill site (behind the Zoo planning building), will be required. Ultimately, some facilities will require removal for the well abandonment as discussed below.
2. Over six million gallons (18 acre-feet) of water will be generated during each pumping test. As previously stated, each pumping test could cost over \$32,000 in City fees if these are not waived. We recommend that the following cost saving alternatives be considered:
 - City and Zoo officials could work out the fee structure to their mutual satisfaction;
 - Some of the pumped water could be used to fill the storage reservoir (pumping rates will completely fill the pool in about two hours). Remaining water could be disposed of into the storm water system;
 - Logistics of piping the water to Lake Merced should be considered (recharge is politically correct these days); however, the cost of this option could be excessive;
 - Water could be piped to topographically low-lying areas south of the Zoo facilities. Up to one million gallons could be stored at a time and allowed to infiltrate. Remaining water could be disposed of into the storm water system.

Well Design Specifications

Well design specifications are a function of the water supply requirements of the Zoo 2000 project, and the hydraulic and engineering properties of the geological materials through the targeted water-bearing sediments. The production wells must be designed to support the necessary pumps to deliver

the required water production rates. One limiting design factor may be the production potential of the water-bearing sediments. In addition, the wells must be designed for municipal water well drilling standards that comply with State and County Environmental Health ordinance and permit requirements.

Each of the Zoo replacement wells will be drilled using the reverse circulation rotary method in which the uncased wall of the drill hole is held in place at all times with a circulation fluid. The proposed well design is provided on Plate 8. A sequential listing of key project activities and specifications is discussed below.

1. Drill a 36-inch-diameter borehole to an approximate depth of 60 lineal feet and install 50 lineal feet of 30-inch (nominal) diameter steel conductor casing up to the ground surface. The annular space of the conductor casing is to be sealed off with a sand/cement grout. This conductor casing depth was selected to protect the well from shallow salt water intrusion. The conductor seal will also prevent downward movement of hydrocarbons, if present in shallow soils.
2. Drill a 12- to 18-inch-diameter pilot borehole to a depth of 520 feet bgs. Borehole cuttings samples are to be collected. Sieve analyses of the borehole cuttings samples will be performed. Deviation of the borehole will be measured at selected depths during the drilling of the pilot borehole.
3. Perform geophysical surveys of the completed pilot borehole. Geophysical logs to be run include spontaneous potential, resistivity, and gamma ray. Design final production well to meet project goals.
4. Ream pilot borehole to a diameter of 28 inches and to a depth of 520 lineal feet. The reamed borehole will be caliper surveyed prior to the installation of the well casing. A 20-foot section of blank steel casing with a steel end cap is to be installed from the bottom of the well screen to a depth of 480 feet. Probable screen intervals should be from 150 to 265 feet bgs and 310 to 460 feet bgs (265 feet of total screen) of 16-inch (nominal) diameter shutter well screen. Blank well casing will be installed between the screen intervals. Screen slot size will be determined from sieve analysis of borehole cuttings. Install 150 feet of 16-inch (nominal) diameter blank steel casing above the upper screen interval.
5. Install a sand pack and sand/cement grout seal in the annular space of the well. The sand-pack size is to be determined from sieve analysis of borehole cuttings.
6. Test the straightness and plumbness of the well casing before and after the placement of the sand pack and after the placement of the sand/cement grout seal.
7. Develop well by air lift swabbing, bailing, and pumping at various depths and rates.

8. Conduct production and water quality testing of well. Production testing will involve a step drawdown test (12 hours of testing) and a long-term, constant-discharge test (3 days of testing).
9. Survey the completed well with a video camera.
10. Construct steel guard posts around finished well and install well cap.
11. Clean up well site.

It is important to note that the proposed preliminary well design specifications meet the municipal water well drilling standards as defined in Water Well Standards: State of California, Bulletin 74-81 and 74-91. Detailed preliminary design specifications are to be presented in the well bid document. Please note that final well design can only be prepared after the drilling of the pilot borehole and associated sieve analysis and geophysical logging.

WELL DESTRUCTION

The City and County of San Francisco Department of Public Health, Bureau of Environmental Health (DPH) will administer the oversight for the two-well destruction (abandonment). Our contact will be Ms. Lorraine Anderson from the 101 Grove Street Central Office. The Zoo wells are classified as irrigation wells and abandonment will follow guidelines as stated in the California State Department of Water Resources, Bulletin 74 Water Well Standards (74-81 and draft 74-90).

A summary of the regulatory requirements and logistical considerations follows:

1. AGS will simultaneously submit the completed **"Application For Well Construction/Well Destruction Or Soil Borings"** and **"Application For Permit To Operate"** forms. DPH will require two \$500 deposit fees: one for destruction and one for construction. The two wells will be covered under each permit. When the new wells are completed, one **"Permit to Operate"** will be issued. See attached forms in Appendix B.
2. A variance will likely be necessary for both wells. We will pursue the variance option because the wells were installed with a cable-tool rig and no data concerning sanitary seals or gravel packs can be located. This variance has been previously granted for similar situations.
3. The DPH recommends the abandonment of Wells No. 3 and 4 within six months after installation of the new wells. Although no specific guidelines are stated, Ms. Anderson believes this will be the maximum grace period DPH will grant.

4. The schedule of events will begin with removal of the turbine pump assemblies with a large Smeal Pump truck, similar to the one in Appendix A, Photo 17. Pulling a pump of this size will require two days for each well.
5. One option is to "overdrill" the casing, pull pipe, and pressure grout (via tremie) to the surface. This option is unrealistic. The outside diameter (OD) of the production string is believed to be 12 inches, but no data is available for the diameter of the outside conductor casing. As a second option, the DPH could require cutting only the upper 50 feet of the cased hole, and then injecting grout into the outside annular space to insure that there is no opportunity for future downward seepage.
6. The third option (and preferable, provided a variance is approved) will involve pressure grouting only, using the tremie method, to within 5 to 10 feet of the ground surface. The weight of the column of cement will "squeeze" through the louvers and into the annular space behind the casing. The capacity of the 12-inch pipe is 0.785 ft³/lineal foot and, at 220 feet in depth, would require a minimum of 6.5 cubic yards (cy) to as much as 10 cy of cement per well. Prearrangement for delivery of cement to the site will be necessary and the drilling subcontractor's responsibility.
7. Each well pad will be broken up, the pump house structure removed, and possibly any trees or bushes in close proximity must be trimmed or removed to facilitate accessibility of the large vehicles. Both well sites are moderately overgrown with vegetation (Plate 9). The logistics to provide access to Wells No. 3 and 4 will be tricky. Whether the DPH provides a well destruction variance or not, the law requires excavation around the well head to a depth of 5 feet. A welder will cut the casing after grouting is complete, and the site will be backfilled and returned to its original condition.

Well No. 3 is reasonably accessible. The small building housing the well head and pump assembly will be completely removed. A large pump truck can pull through the gated driveway directly to the well and remove the turbine pump and shaft without encountering problems. Likewise, excavating around the well should not present too much difficulty.

Well No. 4 is presently inaccessible by heavy equipment. The well housing is located 25 feet south and 10 feet below Sloat Boulevard. Access is blocked from the south entrance (near Well No. 3) by a 13' x 22' shed, as well as a larger building extension, which prevent a backhoe or bobcat from entering the site. Only a narrow cat walk offers access to Well No. 4. At this point, it appears that the shed must be removed and the site leveled to allow vehicles into the area. Access from the paved area to the west provides very little promise because of large trees and other overhead obstructions. Shrub growth has completely covered the pump house, and some will need to be trimmed back. How much shrubbery removal is required will depend on the subcontractor and their equipment sizes.

To keep from removing the shed, the subcontractor could disassemble the pump house, and manually excavate around the well head to meet regulatory needs. This may work only if their pump truck can reach over the shed and remove the turbine pump.

8. The cementing of the well should take one day to complete. After cementing, appropriate time will be given for the cement to set, and the excavation will be backfilled to grade.
9. We have verified with local drilling companies that the well destruction labor and materials may cost as much as \$20,000 per well, not including the logistics of providing access to the well locations.
10. Because of costs to prepare bid specifications, we recommend that a single subcontractor be chosen to perform the new well constructions as well as the existing well destructions.

CONCLUSIONS AND RECOMMENDATIONS

Groundwater resources at the planned Zoo well field area are adequate to support the long-term water supply requirements of the Zoo 2000 project from two replacement water production wells constructed in the confined Colma/Merced and Merced Formations. The potential degradation of the water quality of the groundwater aquifers from salt water intrusion and/or from a surface source is considered non-existent. The planned pumping rates of the replacement wells are not expected to affect the water level of Lake Merced.

Preliminary well system design specifications indicate that two wells could be constructed to meet design goals. One of the wells will be used as a back-up in case the other well malfunctions or during maintenance of the other well. Design specifications stipulate the wells be drilled using a reverse-circulation method of drilling, and that the diameter of the wells be adequate (16-inch-diameter well casing and screen) to contain a 1,250 gpm series line-shaft turbine pump.

The locations of replacement Wells No. 5 and 6 will require close coordination with the Zoo staff to assure that disturbance to the operation of the Zoo is minimized during well construction. Disposal of the water generated during development and testing of the wells may require evaluation of several options, including waiving the fee normally imposed by BERM.

Logistics during destruction of existing Wells No. 3 and 4 will require careful consideration of the alternatives discussed above in order to keep the costs down. A variance will be requested from DPH during the permit process to destroy the wells.

 

LEGEND:

- Proposed Well Location
- Existing Well Location

SCALE:
1" = 320'

WELL NO. 6

SITE PLAN

Kennedy/Jenks Consultants - AGS, Inc., An Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

SOURCE: San Francisco Zoological Gardens Master Plan, Porbo, Inc. 6/94

September 1994

PLATE 1

PACIFIC

APPROXIMATE BOUNDARY
OF EXISTING ZOO

OCEAN

MUSSEL
ROCK

SOURCE: Topographic Map by U.S.G.S., S.F. South 7.5 min. Quadrangle

Contour Interval:
100 feet

LEGEND:

Bedrock Outcrop

SCALE:

1" = 5,000'

Kennedy/Jenks Consultants - AGS, Inc., An Association

San Francisco Zoological Garden
Zoo Infrastructure Master Plan

ELEVATION OF TOP OF BEDROCK
FEET (MSL)

September 1994

PLATE 2

Kennedy/Jenks Consultants - AGS, Inc., An Association
 San Francisco Zoological Gardens
 Zoo Infrastructure Master Plan

September 1994
PLATE 3

LEGEND:

Sand Aquifer

Clay Aquitard

Water Table

SCALE:
 Not To Scale

GEOLOGICAL CROSS-SECTION

GROUNDWATER DIRECTION OF FLOW (GRADIENT: .006)

SOURCE: Map by Pacific Environmental Group -Quarterly Monitoring Report, 1/94

LEGEND:

- C-6 GROUNDWATER MONITORING WELL
- R-2 GROUNDWATER EXTRACTION WELL
- (6.59) GROUNDWATER ELEVATION IN FEET (MSL)
- 5.30' GROUNDWATER SURFACE ELEVATION CONTOUR

SCALE:

1" = 38'

Kennedy/Jenks Consultants - AGS, Inc., An Association
San Francisco Zoological Garden
Zoo Infrastructure Master Plan

GROUNDWATER ELEVATION MAP
FORMER CHEVRON SERVICE STATION 9-0082
2940 SLOAT BOULEVARD AT 47TH AVENUE

September 1994

PLATE 4

SOURCE: Topographic Map by City and County of San Francisco, 7/93

LEGEND:

SCALE:

1" = 20'

Kennedy/Jenks Consultants - AGS, Inc., An Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**PROPOSED LOCATION
WELL NO. 5
(PRESENT SITE CONDITIONS)**

September 1994
PLATE 5A

SOURCE: San Francisco Zoological Gardens Master Plan, Portico, Inc., 6/94

NOTE: The scale on this plate is 1"=80', while on Plate 5A it is 1"=20'.

Kennedy/Jenks Consultants - AGS, Inc., An Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**PROPOSED LOCATION
WELL NO. 5**
(FUTURE SITE CONDITIONS)

September 1994
PLATE 5B

SOURCE: Topographic Map by City and County of San Francisco, 7/93

Kennedy/Jenks Consultants - AGS, Inc., An Association

San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

**PROPOSED LOCATION
WELL NO. 6**
(PRESENT SITE CONDITIONS)

September 1994
PLATE 6A

SOURCE: San Francisco Zoological Gardens Master Plan, Portico, Inc., 6/94

NOTE: The scale on this plate is 1"=80', while on Plate 6A it is 1"=20'.

Kennedy/Jenks Consultants - AGS, Inc., An Association

San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

LEGEND:

SCALE:

1" = 80'

PROPOSED LOCATION

WELL NO. 6

(FUTURE SITE CONDITIONS)

September 1994

PLATE 6B

SAN FRANCISCO ZOO REPLACEMENT WELLS CPM CHART

TASKS:

- I. Preconstruction Tasks
 - Select Well Location
 - Bidding & Contracting
 - Permitting
 - Waste Disposal Alternatives
- II. Exploration Borehole Drilling
 - Exploration Borehole Drilling
 - Geology & Geophysical Logging
 - Production Well Design
- III. Production Well Construction
 - Set Conductor Casing
 - Ream Production Well Borehole
 - Construct Production Well
 - Well Development
 - Alignment Testing
- IV. Well Testing
 - Pumping Test
 - Water Quality Analysis
 - Design Pump System
- V. Pump System Installation
 - Contract & Order Equipment
 - Installation of Pump System
 - Testing of Pump System
- VI. Zoo Wells No. 3 & 4 Abandonment
 - Contract Bidding
 - Permitting
 - Analysis & Waste Disposal

Kennedy/Jenks Consultants-AGS, Inc. an Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

REPLACEMENT WELLS CPM CHART

SCALE:

Not To Scale

Kennedy/Jenks Consultants - AGS, Inc., An Association

San Francisco Zoological Garden
Zoo Infrastructure Master Plan

**ZOO REPLACEMENT WELLS
NO. 5 AND NO. 6
PRELIMINARY WELL DESIGN**

September 1994

PLATE 8

SOURCE: Topographic Map by City and County of San Francisco, 7/93

LEGEND:

- Current Well Locations
- Overhead Lines

SCALE:

1" = 20'

Kennedy/Jenks Consultants - AGS, Inc., An Association
San Francisco Zoological Gardens
Zoo Infrastructure Master Plan

WELL DESTRUCTION LOCATION MAP WELL NOS. 3 & 4

September 1994

PLATE 9

APPENDIX A

PHOTOGRAPHS OF TYPICAL
WELL DRILLING CONDITIONS

PHOTO 1 - CONDUCTOR CASING

PHOTO 2 - REVERSE CIRC. RIG

PHOTO 3 - CONDUCTOR BORTING

PHOTO 4 - BUCKET RIG

PHOTO 5 - DRILLING

PHOTO 6 - DEFINING CAREER GOALS

PHOTO 7 - RIG & MUD PITS

PHOTO 8 - LOUVERED CASING

PHOTO 9 - DOWNHOLE TV CAMERA

PHOTO 10 - DOG HOUSE

PHOTO 11 - E-LOG TRAILER

PHOTO 12 - DOWNHOLE TV CAMERA

PHOTO 13 - DISCHARGE LINES

PHOTO 14 - SILT TRAP/DISCHARGE LINES

PHOTO 15 - 21,000 - GALLON TANK

PHOTO 16 - BAKER TANK

PHOTO 17 - PUMP INSTALLATION

PHOTO 18 - PUMP TEST VEHICLE

PHOTO 19 - DRILL SITE

PHOTO 20 - CEMENT PUMP

APPENDIX B

APPLICATION FOR WELL DESTRUCTION
AND
APPLICATION FOR PERMIT TO OPERATE

City and County of San Francisco

Department of Public Health

July 29, 1994

Chad Nichols
AGS
120 Howard #600
San Francisco, CA 94105

Dear Mr. Nichols,

Regarding the destruction and reconstruction of the irrigation wells located at the San Francisco Zoo, please submit the enclosed applications for both activities. Two \$500 deposit fees will be required; one for destruction and one for construction. The two wells will be covered under each permit, and when the new wells are completed one permit to operate will be issued.

If you have any questions regarding this information, please contact me at 554-2774.

Very truly yours,

Lorraine Anderson
Senior Environmental Health Inspector

enclosures

Application For Well Construction Well Destruction Or Soil Borings

Applic. Date: ____/____/____ Starting Date: ____/____/____ Completion Date: ____/____/____

Job Address/Location: _____

TO BE COMPLETED BY OWNER, CONSULTANT OR DRILLER

Property Owner	Well Owner (If Different)	Consultant/Engineer/Geologist Name
Address	Address of Well Site	Address
City, State, Zip	City, State, Zip	City, State, Zip
Telephone Number	Telephone Number	Telephone Number

Please indicate Type and Number of Proposed Wells/Borings

Geotechnical Investigation:

- ☐ Exploratory Wells
☐ Cathodic Wells
☐ Cone Penetrometer Test
☐ Other _____

Environmental Investigation:

- ☐ Exploratory Holes
☐ Water Extraction Wells
☐ Vapor Extraction Wells
☐ Hydropunch

Monitoring Wells Construction

- ☐ Chemical Leaks
☐ Compliance Wells
☐ Baseline Study
☐ Monitoring Well Destruction

Topographic Features Well is to be constructed:

- ☐ In a Public Sidewalk
 ☐ In a Public Road
 ☐ On Private Property
 ☐ On City Property

Construction Specifications:

Diameter of Well Casing: _____

Annular Seal Depth: _____

Gauge of Casing: _____

Annular Seal Material: _____

Casing Depth: _____

Other Information: _____

Destruction Specifications: Well Diameter: _____ Approximate Depth: _____

 Materials and Procedures
to be Used: _____

 If proposed well is to meet compliance with a Hazardous Materials Permit & Disclosure Ordinance, has the Bureau
Toxics and Safety been contacted? ☐ YES ☐ NO

To be completed by Well Section Staff: Permit #: _____ Project #: _____

Date Issued: ____/____/____ Expiration Date: ____/____/____ Number of Wells: _____

 Inspector ID#: _____ Program Element Code: _____ ☐ Record or ☐ Facility ID#: _____

Based on information on the application and attachment(s) hereto (if any) and subject to approval noted below, permission is hereby granted to commence the described project. Permission to start may be withheld until a field check verifies all statements made on application by Permittee and is also subject to any "General" and "Special" conditions attached.

SITE PLAN

WELL LOCATION (DRAW ACCURATELY) (Recommend using Assessor's Map)

1. Sketch well location to scale, show dimensions to nearest foot.
2. Show a minimum of two dimensions at right angles. Dimensions shall be from the centerline of the closest named streets, roads or highways.
3. Show location of existing wells.

CERTIFICATION BY WELL OWNER/AGENT AND DRILLER/AGENT:

I certify the information above is correct to the best of my knowledge. I certify that the well will be constructed in compliance with the conditions this permit, the San Francisco Health Code and, if applicable, the Hazardous Materials Permit & Disclosure Ordinance of the County/City, as appropriate is my responsibility as the well owner to notify this Bureau of any changes in the purpose of this well from that which is indicated on this application form.

Signature of Well Owner/Agent

Date

C-57

Driller's Licence Number

Signature of Responsible Professional
(No substitution of Signature will be accepted)

Date

Civil Engineer
Registration No.

OR

Engineering Geologist
Certificate No.

Filing Fee:
\$

Receipt Number

Fee Date:

/ /

INSPECTOR'S REPORT

To the Director of Public Health -

After having made a careful inspection of the above case on ____/____/____, and

[] I RECOMMEND the issuance of a New Permit to Operate

[] I DISAPPROVE the issuance of a New Permit to Operate for the following reasons:

Permit For Construction # _____ Approved By: _____ Date: ____/____/____

Inspections: 1. By: _____ Date: ____/____/____ 2. By: _____ Date: ____/____/____

X

Sr. Inspector / Program Manager

Application For Well Construction Well Destruction Or Soil Borings

Applic. Date: ____/____/____ Starting Date: ____/____/____ Completion Date: ____/____/____

Job Address/Location: _____

TO BE COMPLETED BY OWNER, CONSULTANT OR DRILLER

Property Owner	Well Owner (If Different)	Consultant/Engineer/Geologist Name
Address	Address of Well Site	Address
City, State, Zip	City, State, Zip	City, State, Zip
Telephone Number	Telephone Number	Telephone Number

Please indicate Type and Number of Proposed Wells/Borings

Geotechnical Investigation:

- ☐ Exploratory Wells
☐ Cathodic Wells
☐ Cone Penetrometer Test
☐ Other _____

Environmental Investigation:

- ☐ Exploratory Holes
☐ Water Extraction Wells
☐ Vapor Extraction Wells
☐ Hydropunch

Monitoring Wells Construction

- ☐ Chemical Leaks
☐ Compliance Wells
☐ Baseline Study
☐ Monitoring Well Destruction

Topographic Features Well/Soil Boring is to be constructed:

☐ In a Public Sidewalk
 ☐ In a Public Road
 ☐ On Private Property
 ☐ On City Property
 ☐ On State Property

Construction Specifications:

Diameter of Well Casing: _____

Annular Seal Depth: _____

Gauge of Casing: _____

Annular Seal Material: _____

Casing Depth: _____

Other Information: _____

Destruction Specifications: Well Diameter: _____ Approximate Depth: _____

Materials and Procedures

to be Used: _____

If proposed well is to meet compliance with a Hazardous Materials Permit & Disclosure Ordinance, has the Bureau of Toxics and Safety been contacted? ☐ YES ☐ NO and workplan approved on ____/____/____

To be completed by Well Section Staff: Permit #: _____ Project #: _____

Date Issued: ____/____/____ Expiration Date: ____/____/____ Number of Wells: _____

Inspector ID#: _____ Program Element Code: _____ ☐ Record or ☐ Facility ID#: _____

Based on information on the application and attachment(s) hereto (if any) and subject to approval noted below, permission is hereby granted to commence the described project. Permission to start may be withheld until a field check verifies all statements made on application by Permittee and is also subject to any "General" and "Special" conditions attached.

SITE PLAN

WELL LOCATION
(DRAW ACCURATELY)
(Recommend using Assessor's Map)

1. Sketch well location to scale
show dimensions to nearest foot

2. Show a minimum of two
dimensions at right angle:
Dimensions shall be from the
centerline of the closest name
streets, roads or highway:

3. Show location of existing well:

CERTIFICATION BY WELL OWNER/AGENT AND DRILLER/AGENT:

I certify the information above is correct to the best of my knowledge. I certify that the well will be constructed in compliance with the conditions this permit the San Francisco Health Code and, if applicable, the Hazardous Materials Permit & Disclosure Ordinance of the County/City, as appropriate is my responsibility as the well owner to notify this Bureau of any changes in the purpose of this well from that which is indicated on this application form.

Signature of Well Owner/Agent

Date

C-57

Driller's Licence Number

Signature of Responsible Professional
(No substitution of Signature will be accepted)

Date

Civil Engineer
Registration No.

OR

Engineering Geologist
Certificate No.

Filing Fee:

\$

Receipt Number

Fee Date:

/ /

INSPECTOR'S REPORT

To the Director of Public Health -

After having made a careful inspection of the above case on ____/____/____, and

☐ I RECOMMEND the issuance of a New Permit to Operate

☐ I DISAPPROVE the issuance of a New Permit to Operate for the following reasons:

Permit For Construction # _____ Approved By: _____ Date: ____/____/____

Inspections: 1. By: _____ Date: ____/____/____ 2. By: _____ Date: ____/____/____

X

Sr. Inspector / Program Manager

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC HEALTH
BUREAU OF ENVIRONMENTAL HEALTH SERVICES

APPLICATION FOR PERMIT TO OPERATE
A WELL(s)

Date of Application:

Kind of Business

LOCATION

Facility Name

BUS.
TEL. NO.

Permit to be issued in name(s) of, or if Corporation
Specify Corporation name and list principal Officers. (Print)

Home Address and Home Tel. No. (Print)

Type of Well(s):

☐ Monitoring ☐ Drinking ☐ Industrial ☐ Irrigation ☐ Recovery ☐ Other

Name(s) of Property Owner(s): (Print)

Home Address & Home Tel. No. (Print)

* SIGNATURE(S) OF APPLICANT(S)

Partnership, all partners must sign. If Corporation, Authorized Officer must sign

Taken By:

FOR OFFICE USE ONLY

Special Notes

Filing Fee ☐ Well Log ☐ Location of Well(s) (Map)
Number of Wells ☐ Closure of Wells(s)

INSPECTOR'S REPORT

to the Director of Public Health -

After having made a careful inspection in the above case on _____, 19__

RECOMMEND the issuance of a New Permit to operate ☐

DISAPPROVE the issuance of a New Permit to operate ☐ for the following reasons:

PRINCIPAL INSPECTOR

INSPECTOR

TRACT NO. CENSUS TRACT PERMIT NO. TYPE OF PERMIT

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC HEALTH
BUREAU OF ENVIRONMENTAL HEALTH SERVICES

APPLICATION FOR PERMIT TO OPERATE
A WELL(s)

Date of Application: _____

Type of Business _____

LOCATION _____ Facility Name _____

BUS.
TEL. NO. _____

Permit to be issued in name(s) of, or if Corporation
Specify Corporation name and list principal Officers. (Print)

Home Address and Home Tel. No. (Print)

Type of Well(s):

☐ Monitoring ☐ Drinking ☐ Industrial ☐ Irrigation ☐ Recovery ☐ Other

Name(s) of Property Owner(s): (Print) _____ Home Address & Home Tel. No. (Print) _____

* SIGNATURE(S) OF APPLICANT(S)

Partnership, all partners must sign. If Corporation, Authorized Officer must sign

Taken By: _____

FOR OFFICE USE ONLY

Special Notes _____

ing Fee _____ ☐ Well Log ☐ Location of Well(s) (Map)

Number of Wells _____ ☐ Closure of Wells(s)

INSPECTOR'S REPORT

To the Director of Public Health —

After having made a careful inspection in the above case on _____, 19 _____

RECOMMEND the issuance of a New Permit to operate ☐

APPROVE the issuance of a New Permit to operate ☐ for the following reasons:

PRINCIPAL INSPECTOR _____

INSPECTOR _____

DISTRICT NO. CENSUS TRACT PERMIT NO. TYPE OF PERMIT

PROCEDURES FOR OBTAINING A PERMIT
TO CONSTRUCT AND MAINTAIN A WATER WELL

- A. Submit an application for a Permit to Construct a Well. See attached application for specific information required.
- B. Submit a deposit of \$500 for the review of plans, inspection of site, drilling, placement of annular seal, and collection of samples. Inspectional fee services are charged at a rate of \$85.00 per hour. See attached handout on the Plan Review Deposit and Refund Program.
- C. Submit application and filing fee to:

Bureau of Environmental Health Services
Water Quality Control Section
101 Grove Street (Room 217)
San Francisco, CA 94102
- D. The minimum construction standards are contained in the current California State Department of Water Resources Bulletin 74 Water Well Standards (74-81 and draft 74-90).
- E. Drillers may not commence work until the Permit to Construct has been approved. Contact the Water Well Section at least 5 days in advance of drilling at 554-2774.
- F. Advance notice of 5 days must be provided for inspection of the annular seal.
- G. Minimum advanced notice of 5 days must be provided prior to well development and water sampling.
- H. Provide a copy of the Department of Water Resources Well Drillers Report, Form 188, to the Water Well Section within 30 days after completion of the work or prior to obtaining the Permit to Operate.
- I. Once a determination has been made that the well and well water conform to construction standards and meet water quality standards, submit an application for a Permit to Operate a Well. A one-time non-refundable filing fee of \$166 is required for the application. One application is required per site. Make check payable to "Department of Public Health." See attached copy of application form.
- J. The Tax Collector will be notified after the Bureau has approved the Permit to Operate. The Tax Collector will bill the property owner/consultant or other responsible party for an annual license fee of \$42 per well according to the San Francisco Health and Municipal Codes. Please pay the Tax Collector within 5 working days and thereafter the Permit To Operate the well will be issued.
- K. The license fee will be billed annually until the well is abandoned. Contact this Bureau prior to abandonment.

(4448e)

APPENDIX C:

**FINAL REPORT:
INFRASTRUCTURE GEOTECHNICAL STUDY**

FINAL REPORT

INFRASTRUCTURE GEOTECHNICAL STUDY

INFRASTRUCTURE MASTER PLAN
SAN FRANCISCO ZOOLOGICAL GARDENS
SAN FRANCISCO, CALIFORNIA

Prepared for:

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS

Submitted by:

KENNEDY/JENKS CONSULTANTS - AGS, INC.
AN ASSOCIATION

June 1, 1995

FINAL REPORT
INFRASTRUCTURE GEOTECHNICAL STUDY

**INFRASTRUCTURE MASTER PLAN
SAN FRANCISCO ZOOLOGICAL GARDENS
SAN FRANCISCO, CALIFORNIA**

AGS Job No. 920801.10

Prepared for:

**CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS**

Submitted by:

**KENNEDY/JENKS CONSULTANTS - AGS, INC.
AN ASSOCIATION**

June 1, 1995

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1. INTRODUCTION

1.1 GENERAL

This report presents the results of a geotechnical study for the proposed Infrastructure Master Plan for the San Francisco Zoological Gardens (Zoo). The site location, relative to the existing streets and topographic features, is shown on Plate 1 - Site Location Map.

This report includes geotechnical findings, conclusions, and recommendations for planning, design, and construction of the proposed infrastructure facilities at the Zoo. Conclusions and recommendations presented in this report are based on the subsurface conditions encountered in the 21 borings drilled for this study, as well as existing subsurface data from previous studies at the site. The conclusions and recommendations should not be extrapolated to other areas or used for other facilities without our prior review.

1.2 PROJECT DESCRIPTION

The proposed infrastructure facilities addressed in this report include underground potable water, groundwater, reclaimed water, gas, electrical, communication, and sewer lines and associated manholes; two wellhead pads and houses for the proposed replacement groundwater wells; an underground groundwater storage reservoir; a groundwater booster pump station; and a wet weather pump station. The proposed water lines will be 6 to 10 inches in diameter. The proposed sewer lines will be 12 to 48 inches in diameter. The proposed gas lines will be 3/4 to 4 inches in diameter. Electrical and communication lines will be installed in a duct bank. Where feasible, as many of the proposed underground lines will be installed in common utility corridors. The proposed locations of the above proposed facilities are shown on the Infrastructure Master Plan.

Other facilities that are part of the proposed Zoo infrastructure but are not addressed in this report are the Mammal Conservation Center (MCC) and the Avian Conservation Center (ACC). The majority of the MCC will be constructed on top of the underground portion of the Oceanside Water Pollution Control Plant (OWPCP), which was designed for the proposed uses. The ACC is addressed in a separate geotechnical report (AGS, 1994).

1.3 PURPOSE OF STUDY AND WORK PERFORMED

The purpose of this geotechnical study was to explore and evaluate the subsurface conditions at the site in order to develop geotechnical design and construction recommendations for the proposed project elements. This work was part of Task 10 of the work authorized by the 25 August 1993 Notice to Proceed on the 12 July 1993 Agreement between the City and County of San Francisco Department of Public Works, the Zoo, and Kennedy/Jenks Consultants - AGS, Inc., An Association, for Professional Services for the Development of a Zoo Infrastructure Master Plan. The work performed for this study is summarized below.

1. A review of available geologic, topographic, and geotechnical data pertinent to the project site and the proposed construction was performed.
2. A field exploration program, which consisted of drilling 21 borings and installing piezometers in 9 of the borings, was performed at the site. Plate 2 - Boring Location Map, shows the approximate locations of the borings and piezometers. Appendix A - Field Exploration, presents details of the field exploration program.

3. A laboratory testing program was completed. The laboratory program included moisture content, dry density, grain size distribution, Atterberg limits, corrosivity, and R-value tests, as appropriate for the various soils encountered. Appendix B - Field and Laboratory Testing, Appendix C - R-value Test Results, and Appendix D - Corrosivity Test Results, present details and results of the field and laboratory testing programs.
4. Engineering analyses were performed to develop geotechnical conclusions and recommendations.
5. This report was prepared. The report includes:
 - A summary of the site surface and subsurface conditions;
 - A discussion on groundwater elevations;
 - A description of the local and regional geologic conditions;
 - A discussion on faults and seismicity;
 - Results of soil corrosivity tests;
 - Seismic design considerations;
 - Recommendations for excavations and earthwork operations;
 - Foundation design parameters;
 - Recommendations for the design of slabs-on-grade;
 - Lateral earth pressures on underground walls;

- Recommendations for resistance to lateral loads;
- Recommendations for resistance to hydrostatic uplift;
- Pipeline design parameters;
- Pavement design criteria; and
- Design review and construction monitoring considerations.

The intent of this work was to supply the infrastructure designers with sufficient information to proceed without additional field work.

1.4 REPORTS REVIEWED

Several reports in the site vicinity were reviewed as part of this study. Those reports are listed in the References section of this report.

2. FINDINGS

2.1 SITE CONDITIONS

The existing Zoo is located between the Great Highway, Sloat Boulevard, Herbst Road, and the OWPCP in southwestern San Francisco as shown on Plate 1. The ground surface elevations at the Zoo vary from about 5 to 50 feet SFCD (San Francisco City Datum). The lower elevations throughout the Zoo correspond to the approximate location of an old drainage channel that connected Lake Merced with the Pacific Ocean, as shown on Plate 3 - Location of Old Channel. The level area on the west end of the Zoo was formerly occupied by the Fleishhacker Pool, which was filled in by the City. Large portions of the Zoo are covered by trees.

2.2 GEOLOGY

The San Francisco Peninsula lies within the Coast Ranges physiographic province of California, which is characterized by a series of north-northwesterly-trending mountains, valleys, and faults. The Bay Area as it is known today came into existence in mid- to late-Pleistocene time. Rocks of the Franciscan Formation were deposited at the foot of the continental slope from late Jurassic to mid-Cretaceous time. The formations were folded and faulted by a series of earth movements into the northwest-trending structural pattern of the central Coast Ranges. During the end of the Pliocene and the Pleistocene epochs, the San Francisco Marin block was tilted toward the east, with the western edge forming the San Francisco and Marin hills, and the depressed eastern edge forming the uneven depression in which the bay now lies. In Pleistocene time, the trough was partially filled with sediments and became the San Francisco Bay as it was flooded due to the rise in sea level during the interglacial stages (Schlocker, 1970).

The project site is underlain by deep sand deposits. The surficial soils at the site consist of artificial fill which is mainly a reworked dune sand with occasional gravel. The fill sand is underlain by wind-deposited dune sands. The extensive dunes in San Francisco are due to a favorable combination of wind, supply of sand, coastal topography, and limited plant cover. Strong eastward onshore winds are frequent along the ocean beach and longshore currents continuously replenish the supply of dune sands. Dune development was especially active during the periods of rising sea level during the Holocene and perhaps in the Pleistocene.

The dune deposits contain mostly subrounded to subangular grains with essentially no silt or other interstitial fines. The sands have relatively low strength and are low-density materials with relatively high compressibility. Where these deposits have been reworked by ocean currents to produce silty sands, or where beach sands have been deposited, the density is higher and the compressibility potential lower.

The dune sands are underlain by sands of the Colma Formation. The Colma Formation is a complex of Pleistocene coastal and estuarine sediments deposited mostly by water and gravity and, to a lesser extent, by wind in a variety of environments. The formation lies stratigraphically below the latest Pleistocene and Holocene deposits. The Colma Formation consists primarily of friable fine- to medium-grained arkosic sand. Sandy silt and silty sand are locally important constituents. Clay and gravel beds, generally less than 5 feet thick, are also found within the Colma Formation. Bedding is usually distinctive within the Colma Formation. Individual beds, generally 1 to 3 inches thick, vary in the proportion of the silt-clay matrix relative to sand grains. However, the fraction of silt-clay matrix is usually less than 20 percent (Schlocker, 1974). Variations in color may also be distinctive between individual beds.

The Colma Formation lies unconformably on the fossiliferous marine Merced Formation. The Merced Formation was deposited in a shallow marine embayment during the Pliocene and early Pleistocene ages and consists primarily of medium to very fine grained sandstone, with lesser amounts of siltstone and claystone and a few lenses of conglomerate and beds of volcanics. The Merced Formation is believed to be the most likely source of much of the Colma Formation.

Based on available geological and geotechnical data, the bedrock underlying the site is anticipated to be the Franciscan Formation, which consists mainly of shales, sandstones, and metamorphic rocks which are highly sheared and deeply weathered locally. The top of the bedrock beneath the zoo is anticipated to be at depths ranging from 600 to 1,000 feet. The geology of the project area is shown on Plate 4 - Site Geology. A generalized geologic profile is presented on Plate 5 - Geologic Profile.

2.3 SUBSURFACE CONDITIONS

Logs of the borings drilled for this study are presented on Plates A-1.1 through A-1.25 in Appendix A. Based on the data from the 21 borings drilled for this study and available information (Harding-Lawson, 1976; Woodward-Clyde 1977; AGS, 1985, 1988, 1989; Rutherford & Chekene, 1989) from borings at or near the Zoo site, the subsurface materials may be interpreted to consist of surficial artificial fill underlain by dune sands, and silty sand and clay of the Colma Formation. The thickness of the artificial fill is expected to vary from 2 to over 20 feet throughout the Zoo.

Wind-deposited dune sands underlie the surficial fill. The dune sands consist of light gray to brown, poorly graded, fine-grained sand with most grains being subrounded to subangular. The thickness of the dune sand at the Zoo site ranges from less than 10 feet

to over 40 feet. The estimated relative density of the dune sand varies from loose to very dense with most being dense to very dense below elevation -25 feet SFCD. The thickness of loose to medium dense sands is generally greatest along the former drainage channel shown on Plate 3.

The Colma Formation consists of sand and clay. However, gray to dark gray, very dense sand and silty sand comprise the majority of the Colma Formation. The sand/silty sand mix is a fine- to medium-grained sand. Occasionally, a more clayey or silty zone exists near the top of the Colma sands. In 7 out of 21 borings drilled for this study, a 6- to 18-inch-thick layer of organic clay or silt was encountered at depths ranging from 15 to 23 ½ feet (Elevations 5 to -17.4 feet SFCD).

2.4 GROUNDWATER CONDITIONS

2.4.1 Groundwater Level Measurements

Groundwater in the vicinity of the Zoo is interpreted to consist of two aquifers, separated by a laterally discontinuous aquitard. The upper aquifer is an unconfined aquifer which occurs within dune sands and the upper Colma Formation. Based on the existing literature and reports (AGS, 1988; WCC, 1977; Yates, et al, 1990; Harding Lawson, 1981), the present water table for the upper aquifer is estimated to be at an approximate elevation of +8 feet SFCD on the east side and at an elevation of 0 feet SFCD on the west side of the Zoo.

Nine piezometers were installed as part of this study to monitor variations in the elevation of the groundwater level in the unconfined aquifer with time. Table 1 - Groundwater Level

Measurements, presents the depths and elevations of the groundwater level in the unconfined aquifer on November 10 or December 9, 1994, and on February 9, 1995.

TABLE 1
GROUNDWATER LEVEL MEASUREMENTS

BORING NUMBER	DATE (M/D/Y)	DEPTH TO GROUNDWATER (ft)	ELEVATION OF GROUNDWATER (ft)
B-2	12/09/94	7.4	0.0
	02/09/95	6.1	1.3
B-4	12/09/94	6.7	-0.6
	02/09/95	5.2	0.9
B-8	12/09/94	18.5	0.2
	02/09/95	16.8	1.9
B-9	11/10/94	22.4	-2.4
	02/09/95	20.5	-0.5
B-11	12/09/94	19.6	-1.1
	02/09/95	18.0	0.5
B-16	12/09/94	11.7	1.1
	02/09/95	10.3	2.5
B-18	12/09/94	13.1	2.4
	02/09/95	11.7	3.8
B-19	12/09/94	31.5	2.5
	02/09/95	30.4	3.6
B-21	12/09/94	40.3	0.7
	02/09/95	39.3	1.7

As shown in Table 1, the depth to the groundwater level ranged from about 5 feet in Boring B-4 on the western end of the Zoo to about 40 feet in Boring B-21 near the southwestern end of the Zoo, and the elevation of the groundwater level ranged from Elevation 3.8 feet SFCD in Boring B-18 on the eastern end of the Zoo to Elevation -2.4 feet SFCD in Boring B-9 near the southwestern end of the Zoo. Plate 6 - Groundwater Contour Map, shows the

interpreted variation in elevation of the groundwater level in the unconfined aquifer throughout the Zoo on February 9, 1995.

The groundwater level in the unconfined aquifer at the site is affected by the water level at Lake Merced, which is just across Skyline Boulevard to the east. Based on available records between 1988 and 1994, the water level in Lake Merced has ranged between approximately Elevations 4.5 and -3.9 feet SFCD; however, the water level in Lake Merced has been about 7 feet higher than the current level, based on historical records.

2.4.2 Design Groundwater Level

Plate 6 - Groundwater Contour Map, shows the interpreted groundwater levels in the unconfined aquifer on February 9, 1995; however, the groundwater levels in the unconfined aquifer at the site are affected by seasonal fluctuations as well as the water level in Lake Merced. Therefore, we believe it would be prudent to assume a design groundwater level higher than the levels shown on Plate 6. We recommend using a design groundwater level ranging from 7 feet higher than the level on Plate 6 at the eastern portion of the Zoo (closest to Lake Merced) to 5 feet higher than the level on Plate 6 at the northwest corner of the Zoo (furthest from Lake Merced).

2.5 FAULTS AND SEISMICITY

As part of the Coast Ranges geologic province, the San Francisco Bay Area is within a region of high seismic activity. All major faults in this area trend northwesterly and display a similar right-lateral, primarily horizontal movement. The proximity of the site with respect to active and potentially active faults is presented in Table 2 - Active Faults.

TABLE 2
ACTIVE FAULTS

<u>Fault</u>	<u>Approximate Distance to Site (miles)</u>	<u>Fault Length (miles)</u>	<u>Maximum Magnitude (assigned)</u>	<u>Maximum Magnitude (recorded)</u>
San Andreas	2	745	8.3	8.3
Seal Cove - San Gregorio	5	84	7.5	6.1
Hayward	17	45	7.4	6.7
Calaveras	28	71	7.4	6.7

The San Andreas fault dominates the tectonics, geology, and physiography of the San Francisco Bay region. This fault, which extends more than 700 miles northwestward from the Gulf of California to Point Arena, represents the boundary between the North American and Pacific Ocean crustal plates.

The San Bruno fault, classified as "hypothetical" (Bonilla, 1971), passes directly under the Zoo, as shown on Plate 4. The fault is concealed beneath the dune sands and is considered inactive.

2.6 SITE CORROSIVITY

Samples of the in-situ soils from 10 of the 21 borings were tested for resistivity, pH, chlorides, sulfates, and sulfides. The results of these tests and respective corrosivity evaluations are presented in Appendix D. As shown in Appendix D, measured electrical resistivity of the soil samples tested varied from 2,630 to 50,000 ohm-cm; values of pH ranged from 7.4 to 8.2; chloride contents ranged from not detected to 43 parts per million (ppm); and sulfates and sulfides were not detected. Appendix D includes a discussion of appropriate corrosion protection measures for buried pipes at the site.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 PROJECT FEASIBILITY

Based on the results of our field exploration and laboratory testing programs, it is our opinion that it is geotechnically feasible to construct the proposed facilities, provided that the recommendations presented in this report are incorporated in design and construction of the project. The major geotechnical aspects of this project are:

- The potential for seismically-induced settlements of the proposed facilities;
- The shallow depth to groundwater in the low-lying portions of the site; and
- The presence of potentially liquefiable soils (as discussed in Section 3.2.5) in portions of the site.

An evaluation of the potential for contamination of soil or groundwater at the site was not part of the scope of this study.

3.2 SEISMIC DESIGN CONSIDERATIONS

3.2.1 General

The geotechnical seismic design recommendations and geoseismic hazards, considering the site subsurface conditions presented in this report and the seismic sources indicated in Table 2, are summarized below.

3.2.2 Maximum Credible Earthquake

The maximum credible earthquake (MCE) is the largest earthquake that a given fault appears capable of generating. The MCE that could affect the site would be one with magnitude 8.3 occurring along the San Andreas fault at approximately two miles from the project site. The duration of strong shaking for this earthquake would be approximately 60 to 80 seconds. The MCE would have a predominant period of approximately 0.4 seconds at bedrock.

Correlations between distance from a causative fault and mean values of the peak bedrock accelerations and the effects of local soil conditions on peak ground surface accelerations have been developed by Schnabel and Seed (Seed and Idriss, 1982), Campbell (1987), Joyner and Boore (1988), and Idriss (1990). Based on these correlations, an MCE occurring on the nearby San Andreas fault is estimated to generate a peak bedrock acceleration of 0.67 g and a peak ground surface acceleration of 0.52 g at the site.

3.2.3 Site Coefficient

The site coefficient (S-factor) to be used for seismic design depends on the subsurface profile, i.e., the soil thickness (depth to bedrock), soil density, and thickness of soft clay. Based on these criteria, we recommend using an S-factor of 1.2 at the site.

3.2.4 Fault Rupture Hazard

There is no evidence to indicate that the proposed site is located on identified active faults. Therefore, damage due to fault rupture at the site is considered unlikely.

3.2.5 Liquefaction Hazard

3.2.5.1 Liquefaction Potential - Soil liquefaction is a phenomenon in which saturated (submerged) cohesionless soils lose their strength due to the build-up of excess pore water pressure, especially during cyclic loadings such as those induced by earthquakes. In the process, if not confined, the soil acquires a mobility sufficient to permit both horizontal and vertical movements. Soils most susceptible to liquefaction are loose, clean, saturated, uniformly graded, fine-grained sands. Saturated silty and clayey sands may also liquefy during strong ground shaking.

A liquefaction analysis performed by Rutherford & Chekene (1989) for the eastern portion of the Zoo indicated that the majority of the eastern half of the zoo is susceptible to liquefaction during the MCE. The area along the water fowl/flamingos lake (near Borings B-17 and B-18 drilled for this study) was found to be susceptible to liquefaction even during an earthquake of magnitude 6 or less. This area corresponds to the approximate trace of an old drainage channel which connected Lake Merced to the ocean. The results of our liquefaction analysis, discussed below, corroborate these findings.

A liquefaction analysis was also performed as part of this study. Significant factors known to affect the liquefaction potential of cohesionless soils are: the characteristics of the material including relative density, intergranular structure, age, stress/strain history, and grain size distribution; the static in-situ stresses prior to the earthquake; and the characteristics of the earthquake ground motions, including the amplitude and duration of strong ground shaking.

The nature of liquefaction depends greatly on the characteristics of the soils. In loose soils, liquefaction results in significant loss of soil strength which can lead to large

deformations. In dense soils, although a condition of liquefaction can be initiated, the tendencies for loss of strength and deformations are resisted by the dilation of the soils. Deformations in dense soils result in a tendency for soil volume increase (dilation) which in turn results in reduction of pore water pressures, increase in soil effective stresses, and increased resistance to further deformations.

The liquefaction potential of soils at the site was evaluated using a simplified, analytical empirical procedure that is correlated with the liquefaction behavior of saturated sands during historic earthquakes (Seed and Idriss, 1982). The data utilized in the evaluations consisted of SPT and Modified California sampler blow counts. The SPT and Modified California data were obtained from the 21 borings drilled for this study.

The recorded SPT and Modified California sampler blow counts in the field were corrected for various factors, as described by Seed and others (1984), to obtain corrected N-values, which were used in the liquefaction potential evaluation. The factors which were used for correction of blow counts included the effects of overburden pressure, hammer type, sample depth, sampler type and size, and fines content. The details of our correction procedures are presented in Appendix E - Liquefaction Potential and Seismic Settlement Evaluation.

The ratio of the average cyclic shear stress induced by a seismic event to the initial (static) effective overburden pressure was estimated by the simplified procedure described by Seed and Idriss (1982), as discussed in Appendix E.

The corrected N-values versus average cyclic stress ratio for the in-situ cohesionless soils below the groundwater level, and the curve representing the minimum corrected N-values to prevent liquefaction during the MCE, are presented on Plate E-6 - Results of

Liquefaction Analysis. As Plate E-6 indicates, liquefaction is anticipated to occur during the MCE in 9 of the 21 borings drilled for this study. Seven of those eight borings are within the old drainage channel shown on Plate 3, confirming the conclusions by Rutherford & Chekene (1989).

The portions of the Zoo where potentially liquefiable soils have been documented are shown on Plate 7 - Liquefiable Zones. Based on data from the nine borings from this study where potentially liquefiable soils were encountered (B-1, B-4, B-7, B-13, B-14, B-15, B-16, B-17, and B-18), the depth to the bottom of the potentially liquefiable zone ranges from 10 to 20 feet below the existing ground surface. As shown by 7 of the 8 above borings (except B-13), the zones with potentially liquefiable soils are generally within the area where an old channel used to connect Lake Merced to the Pacific Ocean, as shown on Plate 3. The low-lying area in the immediate vicinity of Boring B-13 also seems to be susceptible to liquefaction.

3.2.5.2 Consequences of Liquefaction - The potential consequences of liquefaction at the site include lateral spreading, lurching, bearing capacity failure, increased lateral earth pressures, settlement, and flotation of underground structures. These effects and their severity depend upon the detailed soil characteristics, local topography, the types of structures, and the severity of the earthquake. The effects may develop during and/or following the earthquake. To mitigate the impacts of liquefaction, special seismic resistant design may be required for some structures and soil densification may be required in some areas.

The data on Plates 6 and 7 may be used to estimate whether proposed pipelines or underground structures located within the liquefaction zones shown on Plate 7 will be underlain by potentially liquefiable soils. If the structure is supported at least 20 feet below

the ground surface, it will not be underlain by potentially liquefiable soils, based on available boring data. If the structure is supported less than 20 feet below the ground surface, the nearest available boring and the data on Plate 6 should be used to check if potentially liquefiable loose to medium dense sands below the groundwater level may be present below the structure. Additional discussion regarding differential settlement of structures underlain by potentially liquefiable soils or unsaturated soils subject to seismically-induced settlement is presented in Sections 3.2.8 and 3.9.1.

Lateral spreading could occur along existing slopes such as the slope along Sloat Boulevard. Although stable under static conditions, existing slopes could experience permanent lateral deformation during strong seismic shaking.

During liquefaction, the lateral earth pressure induced by the liquefied soil surrounding the proposed sewer pipe or pump station wet wells would momentarily increase. We recommend using an equivalent fluid weight of 110 pcf to calculate the lateral earth pressure of liquefied soils.

3.2.5.3 Mitigation of Liquefaction Potential - We do not believe that it would be practical or cost-effective to recommend area-wide liquefaction mitigation measures for the proposed utilities. However, suggested mitigations should include special details for the pipeline design, including the use of flexible materials and connections in critical areas, shorter sections of pipe, and other precautions to allow the proposed pipelines to accommodate anticipated seismically-induced settlements.

If the above consequences of liquefaction cannot be tolerated for some structures, some form of liquefaction mitigation could also be considered in some areas. The potential for soil liquefaction may be alleviated by grouting or by removal and replacement of liquefiable

soils. Compaction grouting or chemical grouting of the in-situ sands would reduce their liquefaction potential. Removal of liquefiable soils and replacement with engineered fill may be practical where the thickness of liquefiable soils is small. We recommend that any in-situ soil improvement method be extended to the bottom of the liquefiable zone and cover an area extending at least 10 feet beyond the proposed improvements.

3.2.6 Seismically-Induced Strain

Underground structures may be damaged by seismic ground shaking or vibration, even though an actual fracture or slip of the ground surface does not occur. The axial and bending strains induced in a pipeline by ground shaking can be estimated from the following equations (Newmark, 1967):

$$\text{Axial Strain: } \epsilon_m = V_m/c$$

$$\text{Bending Strain: } k = a_m/c^2$$

Where:	ϵ_m	=	Axial strain on the pipe
	V_m	=	Soil particle velocity
	a_m	=	Soil particle acceleration
	c	=	Wave propagation velocity in the direction of the pipe axis
	k	=	Reciprocal of the radius of curvature

The wave velocities in the direction of the pipe axis can be evaluated using the relationship presented in Coats (1980). It is recommended that the compressive wave velocity (V_p) be

used for the axial wave propagation velocity and the shear wave velocity (V_s) be used for the curvature wave propagation velocity. Peak ground surface particle velocities were evaluated based on the empirical relationships developed by Joyner and Boore (1988), Campbell (1987), and Sabetta and Pugliese (1987). The results of our evaluation indicate that a peak velocity of 7 ft/sec should be used.

The following accelerations, particle velocities, and wave velocities were used in our seismically-induced pipe strain analyses.

a_m (g)	V_m (ft/sec)	V_p (ft/sec)	V_s (ft/sec)
0.52	7	1,600	800

Using the above equations and the velocity and acceleration values, seismically-induced axial and bending strains in the pipes are estimated to be on the order of 0.0044 feet/foot and 0.000026 radians/foot, respectively.

3.2.7 Seismically-Induced Lateral Earth Pressures

Horizontal accelerations during seismic events will momentarily increase lateral earth pressures on underground structures. We recommend using an equivalent seismically induced earth pressure with a rectangular pressure distribution of $F \cdot H$ psf, where F depends on the magnitude of the ground acceleration and H is the height of the underground wall in feet. The resultant seismic force would act at $0.5H$ above the base of the wall. The seismic earth pressures are in addition to the static earth pressures and should be considered in design of the underground structures. Liquefaction-induced earth pressures are discussed in Section 3.2.5.2.

For the peak ground surface acceleration of 0.52 g discussed in Section 3.2.2, and for level backfill conditions, the value of F would be 17; however, for a lower design acceleration, the value of F would also be lower. For a design-level acceleration of 0.30 g, a value of 10 is recommended for the F factor. The above F values are applicable for level backfill conditions only. For 4(h):1(v) and 2(h):1(v) sloping backfill, the above F values should be increased by 10 and 15 percent, respectively, to estimate the seismically-induced earth pressure.

The choice of the value of F to be used for design of the retaining and underground walls at the site depends on the level of risk accepted by the designer. If walls are not designed for seismically-induced earth pressures, consequences during strong earthquake loading might include lateral movement of, or distress to, the walls.

The magnitudes of seismically-induced earth pressures were calculated based on the simplified procedure developed by Seed and Whitman (1970) and incorporated a reduction factor on the order of 20 percent to judgmentally account for possible effects of wave scattering or passage, the transient nature of earthquake ground motions, and possible wall-soil interaction effects.

3.2.8 Seismically-Induced Settlements

Strong earthquake ground shaking could cause settlements due to: (1) compaction of soils above the groundwater level during the earthquake ground shaking; and (2) consolidation of soils below the groundwater level as pore pressures dissipate after the earthquake. Differential settlements will occur due to non-homogeneity of the soils and the presence of looser soil lenses.

We conducted a seismically-induced settlement evaluation as part of our study. The results are presented in Appendix E. Based on existing data, it is estimated that medium dense to dense sands should settle less than 2 inches during strong shaking while loose to medium dense sands may settle over 5 inches. Plate 8 - Seismically-Induced Settlement Zones, presents different zones of the Zoo which are anticipated to experience different amounts of seismically-induced settlements during the MCE. A description of those zones is also presented in Table 3 - Seismically-Induced Settlement Zones.

TABLE 3
SEISMICALLY-INDUCED SETTLEMENT ZONES

Zone*	Potential for Seismically-Induced Settlement	Anticipated Seismically-Induced Settlement During MCE (in.)
I	Low	Less than 2
II	Moderate	2 to 5
III	High	More than 5

* See Plate 8 for approximate zone boundaries.

The boundaries of the zones shown on Plate 8 are only approximate since the conditions change gradually from zone to zone; however, we recommend that they be used as a planning tool to help evaluate the seismically-induced settlement risks across the site.

The anticipated settlements shown on Plate 8 are ground surface settlements during the MCE. Seismically-induced settlements of underground structures will depend on the invert elevations of those structures, and seismically-induced settlements during seismic events smaller than the MCE will be smaller.

Structures underlain by loose to medium dense sands may experience seismically-induced settlements. The approximate seismically-induced settlement of a structure may be

estimated as discussed in Section 3.9.1. The thicknesses of soils subject to seismically-induced settlement in the 21 borings drilled for this study are shown in Table E-2 in Appendix E. Those thicknesses can be assumed to be from the ground surface elevations shown on the boring logs.

The anticipated seismically-induced settlements are expected to be uniform over relatively short distances. It is our opinion that differential seismically-induced settlements should be less than 1 inch per 50 feet horizontally.

3.3 EXCAVATIONS AND EARTHWORK

3.3.1 Site Preparation

Prior to excavation, the existing pavements and slabs should be removed, and debris and the upper few inches of soil should be stripped and disposed of outside the construction limits. Existing underground utilities located within the proposed construction areas, if affected by construction activities, should be relocated prior to excavation. Debris generated from the demolition of underground utilities, including abandoned pipes, should be removed from the site as construction proceeds. If pipes are abandoned in-place, they should be filled completely with lean grout to mitigate the potential for their collapse in the future.

3.3.2 Dewatering

The majority of the utility line excavations will be above the groundwater levels; however, excavations for pump stations and the majority of the trunk sewers will extend below the groundwater level during construction of the proposed project. The contractor should be

responsible for providing an adequate dewatering system during construction. A properly designed, installed, and operated dewatering system should:

- Lower the water table inside the excavation or intercept seepage which will emerge from the sides or the bottom of the excavation;
- Improve the stability of the excavation and prevent disturbance of the bottom of the excavation;
- Provide a reasonably dry working area in the bottom of the excavation; and
- Provide for collection and removal of surface water and rainfall.

It is recommended that the water level be maintained at least two feet below the bottoms of the excavations until the structures are constructed or pipelines are placed, and until the weight of the structures and the backfill soils are sufficient to resist buoyancy.

Selection of the equipment and methods of dewatering should be left up to the contractor, and he should be aware that modifications to the dewatering system may be required during construction, depending on conditions encountered. Because the in-situ soils consist predominantly of clean sands, a relatively high infiltration rate should be anticipated. The anticipated coefficients of permeability for the in-situ sands range between 0.01 and 1 cm/sec, based on gradation data developed for this study. Where cleaner sands are encountered (i.e. sands with very low percentage of fines), the coefficients of permeability may be in the upper portion of that range.

Water collected during dewatering should be tested for contamination prior to its disposal. Because the potential for contamination of groundwater was not explored in this study, recommendations are not given herein for proper disposal of collected water. Based on our experience with the OWPCP and the Lake Merced Tunnel projects in the immediate

site vicinity, we understand that the water generated during dewatering for those two projects was not contaminated. Dewatering water generated during construction of the adjacent OWPCP project was discharged into Lake Merced through a pipe constructed beneath Skyline Boulevard. Dewatering water generated during construction of the nearby Lake Merced Tunnel was discharged both into Lake Merced and directly into the ocean outfall (SWOOP). The water in both projects was tested for water quality on a regular basis prior to discharge, and the results should be available for review.

3.3.3 Temporary Excavations

Excavations must comply with the current requirements of OSHA or Cal-OSHA, as applicable. Additionally, all cuts deeper than five feet should be sloped or shored. Due to space limitations, most of the excavations at the site will be shored; however, shallow excavations above the groundwater level may be sloped if space permits. It is our opinion that temporary excavations may be sloped at 2(H):1(V) or flatter above the groundwater level; however, it is the responsibility of the contractor to maintain safe and stable slopes or design and provide shoring during construction. Flatter slopes will be required if clean or loose sandy soils are encountered along the slope face. Steeper cuts may be utilized for excavations less than five feet deep depending on the strength and homogeneity of the soils as observed in the field.

Heavy construction equipment, building materials, excavated soil, and vehicle traffic should not be allowed within seven feet of the top of excavations.

Based on the results of our field exploration program and our review of available subsurface data, it is our opinion that the majority of the proposed excavations can be made using conventional equipment.

Excavation in the MCC located above the roof of the existing OWPCP should not penetrate into the drainage layer above the roof slab. We understand that the roof is covered with approximately six feet of soil, and the lower foot consists of a gravel drainage layer. We recommend that trenches excavated over the roof of the OWPCP be no deeper than 4 feet below the existing grade.

3.3.4 Shoring

Shoring may be utilized where space or other restrictions do not allow a sloped excavation. Based on the anticipated depth of excavations, it appears that temporary shoring systems consisting of sheet piles or soldier piles and lagging, with or without internal bracing, may be required for some of the proposed excavations. The sheet piles or soldier piles should extend below the excavation bottom as determined by the shoring designer to provide the required lateral support and/or minimize seepage from the bottom of the excavation. Alternatively, trench boxes may be used as an alternative to standard sheeting and shoring.

Preliminary shoring design criteria are presented in Section 3.6.1. It should be noted that the method of installing shoring significantly affects ultimately developed soil pressures and deformations adjacent to the shoring system. The shoring installation program may require grouting of voids behind the shoring if such voids are created during installation or removal.

3.3.5 Construction-Induced Settlements and Effects on Adjacent Structures

In conjunction with the shoring installation, a monitoring program should be set up and carried out by the contractor to determine the effects of the construction on the adjacent structures, streets/driveways, and utilities. Reference points should be set and read prior

to the start of construction activities to establish the pre-existing conditions, and points should be set on the shoring as soon as initial installations are made. Surveys should be made periodically, but more often during construction activities. Additional shoring will be required if large movements are recorded during the surveying program. Underpinning may be required where the proposed excavations may be in close proximity to existing shallow foundations or underground utilities not supported on piles.

Caution should be exercised to minimize deflection of the shoring system and settlements of the ground surface surrounding the excavations as a result of construction activities such as excavation, dewatering, and shoring installation. The designer should determine the allowable deflections and settlements.

3.3.6 Excavation Base Stability

Stability of the base of excavations will be dependent upon the success of the groundwater control system and the dimensions of the excavation. Since excavations will be in granular materials, it is recommended that the groundwater level be maintained a minimum of two feet beneath the bottom of the excavation throughout construction in order to minimize the chance of base failure due to high seepage gradients.

It is the responsibility of the shoring contractor to design and install an adequate shoring system to prevent excessive soil deformation and failure; however, in order to minimize the potential for base instability and to keep ground and support system movement to a minimum, the following should be considered:

- The excavation width should be kept to a minimum;
- Excavations should be performed in segments; and

- Surcharge loading should be minimized or avoided at the ground surface within H feet of the edge of the excavation, where H is the depth of excavation.

3.3.7 Construction Loads

Significant loads may be imposed on the pipes during compaction of the trench backfill by heavy equipment. No heavy construction equipment should be allowed to operate within 2-1/2 feet of the top of the pipes. Caution should be exercised during compaction to avoid damaging the proposed pipes.

3.3.8 Structural Fill and Backfill

Structural fill and backfill may be used for backfilling trenches and behind underground walls during construction of this project. These fills may either be structural or nonstructural. Structural fills are those defined as providing support to foundations, wall footings, pavements, and slabs; nonstructural fills and backfills include all other fills such as those placed for landscaping, and not planned for future structural loads. Structural fills should be compacted to at least 95 percent relative compaction in accordance with ASTM D1557; nonstructural fills should be compacted to at least 90 percent relative compaction.

Structural fill material should be placed in lifts not exceeding approximately 8 inches in loose thickness, brought to near-optimum moisture content in-place, and compacted using mechanical compaction equipment. Nonstructural fills may be placed in lifts not exceeding 12 inches in loose thickness and compacted in a similar manner.

Structural fill soils should be predominantly granular, less than 3 inches in any dimension, free of organic and inorganic debris, and contain less than 20 percent of mostly nonplastic

finer passing the No. 200 sieve. The fill soils should have a liquid limit less than 35 and plasticity index less than 12. It is anticipated that the majority of the excavated on-site soils will meet the above requirements; therefore, excavated soils may be used as engineered fills and backfills provided that they are not contaminated. Fill materials should be observed and tested by or under the supervision of the geotechnical engineer prior to their use in order to evaluate their suitability.

3.3.9 Pipe Bedding

The proposed pipelines should be completely surrounded with bedding material to provide uniform support and protection. Pipe bedding should consist of pea gravel or crushed rock conforming to the gradation requirements presented in Table 4.

TABLE 4
RECOMMENDED PIPE BEDDING MATERIAL

Sieve Size	Percent Passing
1 - ½ inches	100
¾ inches	50 to 100
⅝ inches	8 to 50
# 4	0 to 8
#200	0 to 2

Crushed stone or gravel meeting these requirements includes No. 3 concrete aggregate, as specified in the Standard Specifications for Public Works Construction, and concrete gravel designated ASTM C-33, Gradation 67.

Pipe bedding should be placed beneath and up to the spring line of the pipe. The pipe bedding should have a minimum thickness of six inches beneath the pipe. Native sands can be used as pipe zone fill above the spring line of the pipe. Bedding material and pipe zone fill should be placed carefully to achieve uniform contact with the pipe and have a minimum relative compaction of 90 percent (95 percent in the upper three feet of paved areas) as determined by standard test method ASTM D1557. Compaction by jetting or flooding should not be permitted.

3.3.10 Disposal of Excavated Materials and Groundwater

This study did not assess contamination of on-site soils or groundwater. We recommend that appropriate measures be taken to check and properly dispose of any contaminated excavated soils or groundwater discharged from the site.

3.4 FOUNDATIONS

3.4.1 General

The proposed wet weather pump station, booster pump station, rhinoceros barn (at the MCC), and well houses may be supported on shallow footings or mat foundations bearing in the in-situ medium dense to dense sands. Foundations should extend below any loose surficial sand or fill layers, into medium dense to very dense in-situ sands or on compacted fill. This will minimize static and seismically-induced settlements of the structures.

Recommendations for shallow footings and mat foundations are presented in Sections 3.4.2 and 3.4.3 below, including a discussion of anticipated static settlements. Seismically-induced settlements are discussed in Section 3.2.8. Plans for the proposed structures

were not available at the time of preparation of this report. Therefore, the geotechnical engineer should review the applicability of these recommendations to the structures when plans are available.

3.4.2 Shallow Footings

Shallow spread and strip footings may be used for support of the proposed well houses, rhinoceros barn (at the MCC), and shallow portions of the wet weather and booster pump stations. Differential settlement between the shallow portions of the pump stations and the wet wells (including seismically-induced settlement) should be evaluated once plans are available for the proposed structures.

Footings should be a minimum of 24 inches wide and placed a minimum of 24 inches below the lowest final adjacent grade, and founded on the native medium dense to dense sands or on structural fill. An allowable bearing pressure of 2,500 pounds per square foot (psf) may be used for spread and continuous footings with the above minimum dimensions. For footing widths and depths different than those above, the allowable bearing pressure will also be different. The allowable bearing pressures and footing dimensions for the other MCC facilities which will be constructed on top of the roof of the existing OWPCP should be determined based on the allowable loads on the roof, as specified in the existing design documents for the subject structure.

The bottom of footing excavations above the roof of the OWPCP structure should be at least three feet higher than the top of the roof slab. Care should be taken during excavation not to penetrate into the drainage layer above the roof of the OWPCP. We understand that this drainage layer is at least one foot thick. Therefore, based on the above-recommended 24-inch footing depth, the bottom of the proposed footings is

anticipated to be at least four feet above the top of the OWPCP roof slab, above the existing drainage layer.

The allowable bearing pressure is a net value. Therefore, the weight of the foundation and the backfill over the foundation may be neglected when computing dead loads. The bearing pressure applies to dead plus live load and includes a calculated factor of safety of three. The allowable value may be increased by one-third for dead plus live plus seismic loading conditions. The ultimate bearing pressure is 7,500 psf.

Total static settlements of individual footings will vary, depending on the width of the footing and the actual load supported. Static foundation settlements have been estimated based on anticipated loading conditions for the proposed one-story structures. Static settlements of shallow footings designed and constructed in accordance with the preceding recommendations are estimated to be less than ½ inch. Differential static settlements between similarly loaded, adjacent footings are expected to be less than ¼ inch.

The majority of the static footing settlements are expected to occur rapidly, and should be essentially completed shortly after initial application of the loads. Structural and utility connections to new construction supported on shallow footings should be deferred until a majority of the dead loads have been applied.

3.4.3 Mat Foundations

The wet weather and groundwater booster pump station wet wells may be supported on a mat foundation bearing in the in-situ dense to very dense sands. An allowable bearing pressure of 6,000 psf may be used for the wet well mats. We recommend that a mud slab be constructed at the bottom of the excavation to minimize disturbance of the subgrade.

Total settlements of the wet wells are expected to be less than ½ inch, and differential settlement between opposite ends of the wet wells is anticipated to be less than ¼ inch.

3.5 SLABS-ON-GRADE

Concrete slabs-on-grade for the proposed well houses and MCC/ACC facilities should be supported on a layer of 4 inches of crushed rock or gravel and 2 inches of sand placed over 12 inches of engineered fill as discussed below. Slab subgrades should be rolled smooth prior to slab construction to provide a uniformly dense, non-yielding surface. Requirements for structural fill are presented in Section 3.3.8.

The subgrade beneath slabs-on-grade should be overexcavated to provide for a layer of 12 inches of structural fill plus 4 inches of crushed rock and 2 inches of sand, for a total of 18 inches. The 12-inch-thick layer of structural fill should be placed in accordance with the recommendations in Section 3.3.8. The 4-inch crushed rock and 2-inch sand layers are described below.

A layer, at least 4 inches thick, of clean, open-graded, ¾-inch maximum size rock or gravel should be placed beneath slab-on-grade floors, over the 12 inches of structural fill, to provide a capillary moisture break. This material should be compacted with a vibratory roller and should conform to the gradation criteria presented in Table 5 - Recommended Capillary Break Material.

TABLE 5
RECOMMENDED CAPILLARY BREAK MATERIAL

Sieve Size (U.S. Series)	Percentage Passing
1 inch	100
¾ inch	90 - 100
No. 8	0 - 10
No. 16	0 - 5
No. 200	0 - 3

Moisture vapor is likely to condense on the underside of slab-on-grade floors. If such condensation would be undesirable, a synthetic membrane can be placed over the capillary break. To help provide puncture protection and to aid in slab curing, the membrane can be covered with about 2 inches of clean-washed sand.

For design of slabs and to estimate slab deflections, a coefficient of subgrade reaction of 150 pounds per cubic inch (pci) may be used.

3.6 LATERAL EARTH PRESSURES

3.6.1 Temporary Shoring

Preliminary geotechnical design parameters for the shoring systems are presented on Plate 9 - Preliminary Shoring Design Data. These design parameters include apparent, active, and hydrostatic pressures, lateral surcharge loads, and passive soil resistance. Special cases such as a combination of slope and shoring, or additional loads on retained soils may require an increase in the recommended design values. The contractor's design of the shoring system should take into consideration lateral surcharge pressures induced by construction equipment and stockpiles of excavated materials. It is recommended to avoid stockpiling excavated materials within seven feet of the top of the excavations.

The shoring data presented in this section are preliminary and additional data should be developed as the design of the project progresses. We suggest that the project geotechnical engineer review the shoring calculations and the final shoring plans and specifications.

3.6.2 Permanent Retaining Structures

Retaining walls and underground walls should be designed to retain the backfill, hydrostatic forces, and any additional lateral forces that will be applied due to surface loads placed at or near the walls. Recommendations for the design groundwater level are presented in Section 2.4.2. If no movement is allowed at the top of the underground wall, at-rest earth pressures need to be resisted. If the wall is allowed to deflect outward at the top at least $0.005 H$, where H is the wall height, it may be designed to resist active pressures. We recommend that the active and at-rest pressures be calculated based on equivalent fluid weights of 35 and 55 pounds per cubic foot (pcf), respectively. The choice of at-rest or active conditions should take into consideration the following factors:

- Active pressures are typically used for cantilevered walls that are not too stiff;
- If active pressures are used, some distress may occur to structures supported within the active wedge; and
- At-rest pressures should be used for relatively stiff underground walls or at corners of cantilevered walls.

The above-recommended values assume a backfill soil unit weight of 120 pcf, an angle of internal friction of 33 degrees for the backfill, and an angle of wall friction of zero (Rankine case).

In addition to the above pressures, walls must be designed for anticipated surcharge loads. For line or concentrated loads, Plate 10 - Lateral Surcharge Pressures, Point and Line Loads, and Plate 11 - Lateral Surcharge Pressures, Areal Loads, may be used to calculate the lateral surcharge on restrained retaining walls (at-rest case). For unrestrained retaining walls (active case), the values from Plates 10 and 11 should be reduced by one-third.

About thirty and fifty percent of any uniform areal surcharge placed at the top of an unrestrained and restrained wall, respectively, will act as a uniform horizontal pressure over the entire height of the wall. Traffic loads can either be considered concentrated loads or converted to an equivalent uniform areal load. Where traffic surcharge loads cannot be accurately anticipated, a nominal uniform lateral surcharge pressure of 150 psf could be used for the full height of the walls or to a maximum depth of 20 feet.

To prevent excessive lateral forces from being applied to walls, heavy compaction equipment should not be allowed within seven feet of the tops of the walls. The backfill directly behind the walls should be compacted using small equipment such as self-propelled vibrating plates or rollers.

Consideration should be given to designing underground walls to resist seismically-induced earth pressures. Additional discussion and recommended seismically-induced lateral earth pressures are provided in Sections 3.2.5.2 and 3.2.7.

3.7 RESISTANCE TO LATERAL LOADS

Lateral resistance may be provided by passive pressure against foundations and the embedded portion of underground walls, and by frictional resistance against the bottoms and sides of those elements. Allowable passive pressure behind the walls may be taken as equivalent to the pressure exerted by fluids weighing 300 and 150 pcf above and below the groundwater level, respectively. These allowable values include a calculated factor of safety of at least 1.5.

Friction along the bottoms and sides of the foundations and underground walls may be used in combination with the above allowable passive resistance. The frictional resistance

can be estimated by using a coefficient of friction of 0.40. The net downward load on the foundations should be used to estimate the base friction. The effective at-rest pressures, the pressures normal to the sides of the structural elements, should be used in estimating frictional resistance along the sides. We recommend using equivalent fluid weights of 55 and 26 pcf to estimate the effective at-rest earth pressures above and below the groundwater level, respectively.

The resistance from the upper 24 inches of underground walls should be neglected in lateral capacity calculations; however, the pressure distribution should be calculated from the surface.

3.8 RESISTANCE TO HYDROSTATIC UPLIFT

3.8.1 General

The design groundwater level is discussed in Section 2.4.2. Proposed structures that extend below the groundwater level should be designed to resist anticipated hydrostatic uplift forces.

In addition to the weight of the structure plus any backfill over it, two alternative methods to resist uplift forces are presented below. These include (1) providing extended slab collars at the base of the structures, and (2) using the friction between underground walls and the surrounding soils. Each of these methods is discussed below; however, an adequate mass should be incorporated in the concrete walls and slabs of the structures to minimize the need for additional uplift resistance.

3.8.2 Extended Slab Collars

Uplift forces may be resisted by a combination of the weight of the backfill over the extended slab collar and the shear capacity of the soils above the collar. The portion of the backfill used to calculate the resisting weight should be limited to the zone bounded on one side by the structure and on the other side by an imaginary vertical plane above the upper edge of the collar. The recommended moist unit weight of the backfill is 120 pcf.

In addition, where excavations are sloped rather than shored or where shoring is removed in shallow excavations, the shear capacity of the backfill or existing fill above the collar will provide additional uplift resistance; in excavations where shoring is left in place, this shear capacity would not be applicable. The shear force would act on an imaginary plane extending upward and outward from the upper edge of the collar at a 30-degree angle from the vertical. This shear capacity may be considered equal to the at-rest lateral earth pressure on the shear plane times two-thirds the tangent of the friction angle of soil, as expressed by the formula:

$$R_{\phi} = \sigma_h (2/3 \tan \phi)$$

Where:

R_{ϕ}	=	Available shear capacity in psf
σ_h	=	At-rest effective lateral earth pressure in psf
ϕ	=	Angle of internal friction of the structural backfill

The at-rest effective earth pressure (σ_h) can be estimated using the at-rest criteria in Sections 3.6.2 and 3.7, and increasing the calculated earth pressure by 25 percent to account for the inclination of the shear surface. Values of 0.7 and 0.6 may be assumed for $\tan \phi$ in compacted backfill and existing fill, respectively. The uplift resistance provided

by the shear capacity of the soils above the collar should not exceed 20 percent of the total uplift resistance of each structure.

3.8.3 Side Friction

If a collar is not provided or where shoring is left in place, the friction between the underground walls and the backfill may be added to the weight of the structure to resist uplift forces. The recommendations in Section 3.7 may also be used to estimate the friction along underground walls that can be used to resist uplift. We recommend neglecting the upper 24 inches of underground walls in uplift friction resistance calculations.

3.9 PIPELINE DESIGN

3.9.1 General

The proposed pipelines and duct banks should be supported below the in-situ loose sands to minimize seismically-induced differential settlements. Plate 8 presents the estimated seismically-induced settlements of the ground surface during the MCE, which are a function of the thickness of loose and/or liquefiable sands. The thickness of sands susceptible to seismically-induced settlement below the proposed pipelines should be estimated based on data from the nearest boring. The anticipated seismically-induced settlement of the pipeline could then be roughly estimated by calculating the ratio of the thickness of loose sands below the pipeline over the total depth of loose sands and multiplying it by the estimated seismically-induced settlement from Plate 8. If those anticipated seismically-induced settlements are not acceptable, the loose sands should be overexcavated and recompacted or improved in-situ as discussed in Section 3.2.5.3.

3.9.2 Earth Loads

Loads on the pipe due to the overlying soil on the pipelines will be dependent upon the depth of placement, the backfill type and placement, and the type of pipe. The earth load on the pipe may be calculated using formulas developed by Marston (1930), in accordance with the American Concrete Pipe Association (ACPA) Handbook (1980). It is likely that the pipes will be placed in trenches with near vertical sides; however, fill will most likely be placed over the trench. Because current plans call for a common corridor for all utilities, pipelines may be in an embankment condition, either positive or negative projecting. The designer should determine if the pipe will be in a "trench" or "embankment" condition.

Earth loads on the jack-and-bore section of the sewer pipe may be estimated as the full overburden of earth above the pipeline.

3.9.3 Surcharge Pressures

For any surcharge applied on the pipe, the pressures on the pipe may be estimated using the pressure diagrams presented on Plate 12 - Vertical Surcharge Pressures, and Plates 10 and 11 for lateral surcharge pressures.

3.9.4 Moduli of Soil Reaction

Underground pipes are typically designed to limit deflections caused by the applied loads. These deflections can be estimated with the aid of equations developed by Spangler (1941). Moduli of soil reaction of 1,500 or 2,000 pounds per square inch (psi) can be assumed for the proposed pipelines at the site supported on sand or crushed rock/gravel, respectively.

3.9.5 Thrust Resistance

Where the proposed pipeline changes direction abruptly, resistance to thrust forces can be provided by mobilizing frictional resistance between the pipe and surrounding soil, by the use of a thrust block, or by a combination of the two.

The frictional resistance can be calculated utilizing a coefficient of friction between the pipe and adjacent backfill of 0.30 for steel pipe and 0.40 for concrete pipe. Pipe segments may be connected by tension joints capable of transmitting the required thrust forces if more than one segment of pipe is needed.

Passive resistance at a thrust block may be used instead of, or in conjunction with, frictional resistance to resist pipe thrust. For thrust blocks that are used in fill, equivalent fluid weights of 300 and 150 pcf should be used for above and below the groundwater level, respectively.

3.9.6 Trench Width

Minimum trench widths should be provided in order to ensure uniform support and to minimize external loads on the pipe. We recommend that the width of the backfill, as measured from the side of the pipe to the side of the trench, be a minimum of 12 inches.

3.10 PAVEMENT DESIGN

The six R-value tests performed for the Zoo Infrastructure geotechnical study indicate that the surficial in-situ sands at the Zoo have R-values ranging from 62 to 73, as shown in

Appendix C. Therefore, we recommend using a design R-value of 62 for the pavement subgrade materials at the site.

Prior to pavement construction, the pavement subgrade should be overexcavated to a depth of 6 inches, moisture conditioned to at least 2 percent above optimum moisture content, and recompact to at least 95 percent relative compaction as per ASTM D1557. The pavement subgrade should be proofrolled prior to pavement construction to identify loose or "pumping" areas. Any such areas should be overexcavated and recompact until a firm, unyielding subgrade is achieved.

3.11 DESIGN REVIEW AND CONSTRUCTION MONITORING

We recommend that the geotechnical aspects of design be reviewed by the geotechnical engineer during the design process. We further recommend that earthwork, excavations, and foundation construction be monitored during construction by a geotechnical engineer, including:

1. Excavations and dewatering;
2. Shoring installation, testing/monitoring program, and removal;
3. Foundation excavations, prior to concrete placement; and
4. Placement and compaction of pipe bedding, fills, and backfills.

The soil and groundwater conditions encountered during construction should be observed to verify the applicability of the recommendations presented in this report to the soil conditions encountered, and to recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

Field density tests should be taken during subgrade preparation and placement and compaction of engineered fill and backfill.

4. CLOSURE

This report was prepared for the exclusive use of the CCSF and the Zoo and other members of the design team for specific application to the proposed Zoo Infrastructure Master Plan Project in San Francisco, California. The report was prepared in accordance with generally accepted professional geotechnical engineering practice. No other warranty, either express or implied, is made.

The analyses and recommendations submitted in this report are based upon data from 21 borings performed for this study, as well as available geotechnical data. The nature and extent of variations between the borings may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

The information in this report is primarily intended for design engineers; therefore, it is the contractor's responsibility to evaluate the subsurface conditions at the site. The contractor should also be responsible for all safety aspects of construction. Also, it is the responsibility of the owner or its representative to ensure that the applicable provisions of this report are incorporated into the plans and specifications and that the necessary steps are taken to see that the contractors carry out such provisions in the field.

The use of this report or its contents requires prior consent of the CCSF or the Zoo. In addition, the use of any information contained in this report for purposes other than those expressly stated in it is at the user's own risk.

Respectfully submitted,

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SITE

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SCALE MILES

REFERENCE:
USGS 7.5 Minute Topographic Map, San
Francisco, Ca., South Quadrangle, 1956
photorevised 1980.

SITE LOCATION MAP
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE: 1/95

PLATE 1

NOTES:

1. Borings B-1, B-3, B-5, B-6, B-7, B-10, B-12, B-13, B-14, B-15, B-17, and B-20 were backfilled with cement grout.
2. Borings B-2, B-4, B-8, B-9, B-11, B-16, B-18, B-19, and B-21 were completed as piezometers.
3. See Appendix A for logs of borings B-1 through B-21.
4. Logs of soil borings for previous studies are not included in this report.

LEGEND:

- ◆ SOIL BORING FOR THIS STUDY
- ◆ SOIL BORING COMPLETED AS A PIEZOMETER FOR THIS STUDY
- ◆ SOIL BORING BY AGS AND/OR OTHERS FOR PREVIOUS STUDIES

BORING LOCATION MAP
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801 DATE: 1/95

PLATE 2

SOURCE: TOWILL Inc., 9/93

NOTES:

1. Boundaries were interpreted using data from available maps, topographic surveys, and applying engineering judgement.
2. Actual conditions may vary.
3. See Sections 2.1 and 2.3 of text for additional discussion
4. The boundaries of the zones shown by dashed lines are only approximate since the conditions change gradually.
5. The various references used to develop this plate show slightly different locations of the channel. However, all those locations fall within the boundaries shown on this plate.

SCALE (FEET)

LEGEND:

APPROXIMATE BOUNDARY OF ZONE WHERE OLD CHANNELS WERE
SHOWN ON AVAILABLE MAPS REVIEWED

REFERENCE: Archive maps of San Francisco available at the main library:
Crocker Guide Maps, 1883, 1893, and 1895.

SOURCE: TOWILL Inc., 9/93

LOCATION OF OLD CHANNEL
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO. : 920801

DATE : 1/95

PLATE 3

Depth range (ft)	Geologic Units	
2 to 40	Fill (El. of water table 0 to 8 feet SFCD)	
10 to 40	Dune Sands
40 to between 600 and 1,000	Colma and Merced Formations (primary aquifer zones)
Below 600 to 1,000	Franciscan Group/Great Valley Sequence

SOURCE: 1. Phillips, et. al., 1993, "Geohydrology, Water Quality, and Estimation of Ground-Water Recharge in San Francisco, CA, 1987-1992", U.S.G.S. Water-resource Investigation Report 93-4019.

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GEOLOGIC PROFILE
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE 5

NOTES:

1. Contours were interpreted using data from available piezometers and applying engineering judgement.
2. Actual conditions may vary.
3. See Section 2.4 of text for additional discussion.
4. The contours shown by dashed lines are only approximate since the conditions change gradually.
5. See the logs of borings B-2, B-4, B-8, B-9, B-11, B-16, B-18, B-19, and B-21 in Appendix A and Table 1 in text for actual groundwater levels in piezometers installed for this study.
6. Groundwater levels may be different at different times.

LEGEND:

--- GROUNDWATER LEVEL ELEVATION IN FEET SFCD
MEASURED ON 02/09/95

AGS, Inc.
CONSULTING ENGINEERS

GROUNDWATER CONTOUR MAP
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

JOB NO. : 920801

DATE : 1/95

PLATE 6

NOTES:

1. Boundaries were interpreted using data from available borings, maps, topographic surveys, and applying engineering judgement.
2. Actual conditions may vary.
3. See Section 3.2.5 of text and Appendix E for additional discussion.
4. The boundaries of the zones shown by the shaded areas are only approximate since the conditions change gradually. This plate should be used as a qualitative planning tool only.
5. This plate should be used together with Plates 3 and 8 in evaluating seismic hazards at the site.
6. The soils in the zones shown on this plate may liquefy during the MCE; however, during smaller earthquakes the liquefaction potential may be low.

LEGEND:

APPROXIMATE LIMITS OF ZONES UNDERLAIN BY SOILS
SUBJECT TO LIQUEFACTION DURING THE MCE

LIQUEFIABLE ZONES
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

SOURCE: TOWILL Inc., 9/93

JOB NO.: 920801

DATE: 1/95

PLATE 7

NOTES:

1. The boundaries of the zones were interpreted using data from available borings, maps, topographic surveys, and applying engineering judgement. Actual conditions may vary.
2. See Section 3.2.8 of text and Appendix E for additional discussion.
3. The boundaries of the zones shown by the dashed lines are only approximate since the conditions change gradually. This plate should be used as a qualitative tool only.
4. This plate should be used together with Plates 3 and 7 in evaluating seismic hazards at the site.
5. The seismically-induced settlements shown on this plate are ground surface settlements during the MCE. Ground surface settlements during smaller seismic events or settlements of underground structures should be lower.
6. Zones are defined as follows:

ESTIMATED SEISMICALLY-INDUCED SETTLEMENT (inches)	
ZONE	
I	Less than 2
II	2 to 5
III	More than 5

LEGEND:

- ZONE I
- ZONE II
- ZONE III
- APPROXIMATE BOUNDARY OF SEISMICALLY-INDUCED SETTLEMENT ZONE

DRIVING PRESSURES (PSF)

LEGEND:

- H = EXCAVATION DEPTH, IN FEET
- Z = DEPTH BELOW TOP OF EXCAVATION, IN FEET
- Zw = DEPTH OF GROUNDWATER LEVEL, IN FEET
- D = DEPTH BELOW BOTTOM OF EXCAVATION, IN FEET

NOTES:

1. Use apparent pressure for bracing design above excavation bottom, and active pressure below it.
2. Add surcharge pressures to apparent pressure. If surcharges are kept "H" feet behind shoring, lateral surcharge will be negligible.
3. Minimum shoring penetration (Dmin) for stability purposes only should be determined by balancing driving and resisting pressures.
4. Lateral surcharge pressure shown is a nominal value for traffic only. Actual values should be based on anticipated surcharges. Additional lateral surcharge pressures should be added to the nominal value shown above, as appropriate.
5. It is assumed that the shoring/dewatering system will prevent significant seepage forces from developing.
6. Apparent pressures include hydrostatic pressures.

NOT TO SCALE

PRELIMINARY SHORING DESIGN DATA
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO. : 920801

DATE : 1/95

PLATE 9

REFERENCE:
NAVFAC DM - 7.2, DATED MAY 1982.

LATERAL SURCHARGE PRESSURES
POINT AND LINE LOADS
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE: 1/95

PLATE 10

$$p_{(z)} = q \times I_p$$

p = LATERAL PRESSURE

q = SURCHARGE

L = LENGTH PARALLEL TO EXCAVATION

B = LENGTH PERPENDICULAR TO EXCAVATION

$$m = \frac{B}{Z}, \quad n = \frac{L}{Z}$$

REFERENCE:
NAVFAC DM - 7.2, DATED MAY 1982.

LATERAL SURCHARGE PRESSURES
AREAL LOADS
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE 11

REFERENCE:

NAVFAC DM - 7.1. DATED MAY 1982.

VERTICAL SURCHARGE PRESSURES
 SAN FRANCISCO ZOO
 INFRASTRUCTURE MASTER PLAN

AGS, Inc.
 CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE 12

APPENDIX A

FIELD EXPLORATION

A.1 EXPLORATION

Subsurface exploration for this study was performed between October 25 and November 9, 1994. Twenty-one borings, designated B-1 through B-21, were drilled to depths ranging from 26 to 61-½ feet at the locations shown on Plate 2.

All borings were drilled with a truck-mounted, rotary-wash drill rig provided by Pitcher Drilling Company of Palo Alto. Nine of the borings were converted into piezometers. Following completion of drilling and sampling, the borings not converted into piezometers were backfilled with cement grout. The ground surface at each boring location was restored to its original condition. The materials encountered were logged at approximate 5-foot intervals in the field during drilling operations. Logs of the borings, presented on Plates A-1.1 through A-1.25, give descriptions and graphic representations of the materials encountered, the depths at which samples were obtained, and the field and laboratory tests performed. A legend to the logs is shown on Plate A-2.

Nine soil borings (B-2, B-4, B-8, B-9, B-11, B-16, B-18, B-19, and B-21) were completed as piezometers after drilling and sampling activities. The piezometers were constructed using 2-inch-diameter schedule 40 PVC factory slotted well screen and blank sections. Monterey #3 sand was placed in the annular space throughout the entire screen interval, followed by a 1 to 2-foot-thick bentonite seal. Cement grout was placed from the top of the bentonite seal to approximately 1 foot below the ground surface. Piezometers B-2, B-4, B-8, B-11, B-18, and B-19 were completed with a traffic-rated vault box with waterproof locking caps on each well. Piezometers B-9 and B-21 were completed with 3-foot steel risers with locking tops and waterproof well caps on the top of the wells. Well construction details are presented on Plate A-3.

All drilling waste, or "cuttings," were disposed of on-site at an area designated by the San Francisco Zoo staff.

A.2 SAMPLING

Representative relatively undisturbed soil samples were obtained with a California Modified split-spoon sampler, and disturbed samples were taken with a Standard Penetration Test (SPT) sampler. Both samplers were driven with a 140-pound hammer, falling 30 inches for an 18-inch sampler penetration, where possible. Blow counts required for driving the samplers were recorded at 6-inch intervals for each sample taken. Where the sampler was driven less than 18 inches because of excessive resistance to driving, the initial 6-inch drive was neglected and the number of blows for the remaining portion of the drive was recorded.

Bulk samples for R-value testing were collected from six borings in 5-gallon buckets from material encountered in the upper 5 feet.

LOG OF BORING B - 1			DRILLING DATE: 10/25/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 6.1 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					SAND (SP), yellow brown, damp, medium dense					RV
1		1	14				3			
5		2	11		brownish yellow		7			WA (1%)
10		3	16		saturated		20			WA (2%)
15		4	51		dense					
20		5	70		very dense					
25		6	56		dark gray					
30		7	67							
35		8	50 5"		coarse sand					
40										

JOB NO. 920801.10	PROJECT: S.F. ZOO INFRASTRUCTURE M/P	SHEET 1 OF 2	PLATE A-1.1
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LOG OF BORING B - 1		DRILLING DATE: 10/25/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb falling 30 in.		SURFACE ELEV.: 6.1 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	BLOW COUNT	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION		DRY DENSITY (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
40		9	51	SAND (SP), coarse, saturated, very dense with gravel increasing silt, dark brown					
45		10	62						
50		11	58						
Boring terminated at a depth of 51.5 feet on 10/25/94.									
55									
60									
65									
70									
75									
80									

JOB NO. 920801.10	PROJECT: S.F. ZOO INFRASTRUCTURE M/P	SHEET 2 OF 2	PLATE A-1.2
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LOG OF BORING B - 2			DRILLING DATE: 10/26/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.			SURFACE ELEV.: 7.4 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM			AGS, Inc. CONSULTING ENGINEERS		
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS	
0					ASPHALT CONCRETE (4 in.) BASEROCK, gravel (8 in.)						
1		1	35		SAND (SP), brownish gray, damp, medium dense to dense					CO	
5		2	20		dark brown		3				
10		3	22		dark brown, saturated		19			WA (2%)	
15		4	37		olive gray					CO	
20		5	15				23				
25		6	50		SILT (ML), black, damp, stiff, low plasticity, organic material SAND (SP), grayish brown, saturated, dense						
30		7	58		brown						
35		8	47		gray						
40					Boring terminated at a depth of 36.5 feet on 10/26/94. Boring completed as a piezometer on 10/26/94.						
JOB NO. 920801.10			PROJECT: S.F. ZOO INFRASTRUCTURE M/P			SHEET 1 OF 1		PLATE A-1.3			

LOG OF BORING B - 3		DRILLING DATE: 11/03/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 35 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS				
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					"FILL"					
		1	12		SAND (SP), brown, medium dense, dry, wood fragments					CO
5		2	11				2			WA (1%)
10		3	20		SAND (SP), olive, medium dense, wet, fine grained		17			
15		4	13		dark brown		17			WA
20		5	39		yellow brown, dense					
25		6	52		very dense					
30		7	56		black					
35					Boring terminated at a depth of 31.5 feet on 11/3/94.					
40										

LOG OF BORING B - 4			DRILLING DATE: 10/24/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.			SURFACE ELEV.: 6.1 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM			AGS, Inc. CONSULTING ENGINEERS		
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS	
0					ASPHALT CONCRETE (2 in.)						
					BASEROCK (12 in.)						
1		1	10		SAND (SP), brown, fine grained, damp, medium dense		2			WA (2%)	
5		2	12		yellow brown, moist		14			WA (1%)	
					2/09/95						
					12/09/94						
10		3	27		gray, saturated		20				
15		4	33		medium brown, dense		21				
20		5	50		medium gray, very dense						
			5"								
25					CLAY (CL), silty, organic material, gray						
		6	72		SAND (SP), dark gray, fine to medium grained, saturated, very dense						
30											
		7	58								
					Boring terminated at a depth of 31.5 feet on 10/24/94. Boring completed as a piezometer on 10/24/94.						
35											
40											
JOB NO. 920801.10			PROJECT: S.F. ZOO INFRASTRUCTURE M/P			SHEET 1 OF 1			PLATE A-1.5		

LOG OF BORING B - 5			DRILLING DATE: 11/07/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 45 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					"FILL"					
					SAND (SP), red-brown, gravelly, medium dense, damp					
		1	18				2			
5					SAND (SP), yellow brown, fine to medium grained, medium dense, damp					
		2	14				1			WA (1%)
10					dark brown, dense					
		3	35				16			WA (1%)
15					very dense, increasing grain size					
		4	77				14			
20					yellow brown					
		5	53				28			
25					dense					
		6	32							
30					dark brown					
		7	35							
35										
		8	42							
					Boring terminated at a depth of 36.5 feet on 11/7/94.					
40										

LOG OF BORING B - 6			DRILLING DATE: 10/24/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.			SURFACE ELEV.: 6.4 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM			AGS, Inc. CONSULTING ENGINEERS		
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS	
0					ASPHALT CONCRETE (4 in.)						
					BASEROCK (12 in.)						
1		1	9				1			RV WA (.3%)	
5		2	11		SAND (SP), yellow brown, fine grained, loose to medium dense, moist		9			WA (1%)	
10		3	52		very dense					CO	
15		4	53		dark gray		18				
20		5	26								
		6	54		SILT (ML), dark gray, stiff, moist, trace of sand, organic material		20				
					SAND (SP), dark gray, fine grained, dense, saturated						
25		7	47								
30		8	50 6"		very dense						
35		9	50 3"		Shell fragments						
40		10	50 3"		Boring terminated at a depth of 40 feet 10/24/94.						
JOB NO. 920801.10			PROJECT: S.F. ZOO INFRASTRUCTURE M/P			SHEET 1 OF 1			PLATE A-1.7		

LOG OF BORING B - 7			DRILLING DATE: 10/25/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Failing 30 in.		SURFACE ELEV.: 7.1 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS					
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION			DRY DENSITY (p/CF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					ASPHALT CONCRETE (3 in.)							
					CEMENT (3 in.)							
					BASEROCK (12 in.)							
1		1	7		SAND (SP), yellow brown, fine grained, loose, moist				3			WA (1%)
5		2	12		medium dense				3			WA (1%)
10		3	34		dense				19			
15		4	12		medium dense							
					SILT (ML), dark brown, stiff, moist, trace of sand, organic material							
20		5	26		SAND (SP), dark gray, fine grained, medium dense, saturated							
25		6	71		very dense							
30		7	50		CLAY (CL), blue gray, silty, stiff, moist, organic materials							
			4"		SAND (SP), dark gray, fine grained, saturated, very dense							
					Boring terminated at a depth of 31.5 feet on 10/25/94.							
35												
40												
JOB NO. 920801.10					PROJECT: S.F. ZOO INFRASTRUCTURE M/P			SHEET 1 OF 1		PLATE A-1.8		

LOG OF BORING B - 8			DRILLING DATE: 10/31/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 18.7 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					CLAYEY SAND (SC), dark brown, medium dense, damp					RV
1		1	23		SAND (SP), medium brown, fine grained, loose					CO
5		2	9		tan		1			WA (1%)
10		3	10		dark brown		16			WA (1%)
15		4	29		medium dense					CO
20		5	47		yellow brown, dense					
25		6	46		dark gray					
Boring terminated at a depth of 26.5 feet on 10/31/94. Boring completed as a piezometer on 10/31/94.										
30										
35										
40

 2/09/95

 12/09/94

LOG OF BORING B - 9			DRILLING DATE: 11/03/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 20 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0										
1		1	26		SAND (SP), light brown, fine grained, medium dense, moist, medium dense		3			RV
5		2	13		medium brown		4			WA (3%)
10		3	32		dark brown, dense		18			
15		4	50		yellow brown					
20		5	37		yellow brown					
25		6	39							
30		7	57		very dense					
35					Boring terminated at a depth of 31.5 feet on 11/3/94. Boring completed as a piezomter on 11/3/94.					
40

 2/09/95

 11/10/94

LOG OF BORING B - 10			DRILLING DATE: 11/02/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 20 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					"FILL"					
		1	33		SANDY GRAVEL (GP), brown, medium dense, dry, angular asphalt fragments		2			
5		2	11		concrete fragment (12 in.)		5			WA (8%)
10		3	62		SAND (SP), brown, dense, fine to medium grained, wet		15			
					gravel lenses from 13 to 14 feet					
15		4	9		SILT (OL), dark brown, medium stiff, damp, organic		27			
					SAND (SP), dark gray, medium dense, wet					
20		5	25							
25		6	84		yellow brown, very dense					
30		7	50 4"		dark gray					
35		8	33		dense, with organic debris					
40		9	50 5"		Boring terminated at a depth of 40 feet on 11/2/94.					

LOG OF BORING B - 11			DRILLING DATE: 11/01/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 18.5 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					SAND (SP), light brown, fine grained, medium dense, dry					
1		1	19				1			
5		2	27		brown		13			
10		3	19		dark brown		6			WA (4%)
15		4	32		yellow brown with iron staining, dense					
20		5	74		very dense, wet					
25		6	59							
30		7	25		SILT (OL), brown, medium dense, damp compacted peat					
35					Boring terminated at a depth of 31.5 feet on 11/1/94. Boring completed as a piezometer on 11/1/94.					
40										

LOG OF BORING B - 12			DRILLING DATE: 11/01/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 20 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					SAND (SP), light brown, fine grained, medium dense, dry					
1		1	16				1			
5		2	6		gravel <0.5" brown, loose		1			WA (1%)
10		3	10		dark brown		18			WA (1%)
15		4	15		gray		7			
20		5	62		dark brown, very dense					
25		6	82							
30		7	74		greenish brown					
					Boring terminated at a depth of 31.5 feet on 11/1/94.					
35										
40										

LOG OF BORING B - 13			DRILLING DATE: 10/31/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 16 ft DATUM: SFC LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					ASPHALT CONCRETE (3 in.)					
					BASEROCK (12 in.)					RV
1		1	13		SAND (SP), yellow brown, fine grained, medium dense, damp		1			WA (1%)
5		2	5		loose					CO
10		3	13		dark brown, medium dense		20			WA (1%)
15		4	13		yellow brown		23			
					trace of organic material					
20		5	80		dark gray, very dense					
25		6	50 6"							
					Boring terminated at a depth of 26 feet on 10/31/94.					
30										
35										
40										

LOG OF BORING B - 14			DRILLING DATE: 10/27/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.			SURFACE ELEV.: 15 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM			AGS, Inc. CONSULTING ENGINEERS		
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS	
0					ASPHALT (3 in.)						
					BASEROCK (10 in.)						
1		1	22		SAND (SP), yellow brown, fine grained, medium dense, dry		1				
5					loose						
2		2	2							CO	
10					dark brown		13			WA (1%)	
					increasing density						
15					dense		19				
4		4	39								
20					dark gray, medium dense		23			WA (3%)	
					trace of organic material						
5		5	15								
25											
6		6	27								
Boring terminated at a depth of 26.5 feet on 10/27/94.											
30											
35											
40											
JOB NO. 920801.10			PROJECT: S.F. ZOO INFRASTRUCTURE M/P			SHEET 1 OF 1		PLATE A-1.15			

LOG OF BORING B - 15			DRILLING DATE: 10/26/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 6.0 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					"FILL"					
					SAND (SP), dark brown					
		1	15		CONCRETE (6 in.)		10			
5					SAND (SP), yellow brown, fine grained, medium dense, moist					
		2	15		dark gray		13			WA 13%
10					dark brown, dense		17			
		3	30							
15					medium dense					
		4	27							
20					dense, with trace gravel (<0.5")					
		5	42							
25					yellow brown, very dense					
		6	67							
					Boring terminated at a depth of 26.5 feet on 10/26/94.					
30										
35										
40										

LOG OF BORING B - 16			DRILLING DATE: 10/27/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 12.8 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					CLAYEY SAND (SC), dark brown, loose, moist					
1	▲	1	6		SAND (SP), brownish yellow, fine grained, loose, dry		1			
5					rock fragments					
2	▲	2	2				1			WA (2%)
10	▲	3	16		iron staining, medium dense		16			WA (2%)
				2/09/95 12/09/94					
15	▲	4	8		SILT (OL), organic, soft, damp, sandy		41
				SAND (SP), dark gray, fined grained, medium dense, wet					
20	▲	5	28		increasing density					
25	▲	6	45		gravel, 2" dense					
30	▲	7	52		very dense					
35	▲	8	31		dense dark gray					
40	▲	9	73		Boring terminated at a depth of 40 feet on 10/27/94. Boring completed as a piezometer on 10/27/94.					
JOB NO. 920801.10			PROJECT: S.F. ZOO INFRASTRUCTURE M/P			SHEET 1 OF 1		PLATE A-1.17		

LOG OF BORING B - 17			DRILLING DATE: 10/28/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 15 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					"FILL"					
					SAND (SW), gravelly, fine to coarse grained					RV
1		1	10		SAND (SP), light brown, fine grained, loose, dry		2			
5		2	7				2			WA (1%)
10		3	17		medium brown, medium dense		15			
15		4	13							
20		5	38		dark gray, dense					
25		6	61		very dense					
					Boring terminated at a depth of 26.5 feet on 10/28/94.					
30										
35										
40										

LOG OF BORING B - 18			DRILLING DATE: 10/28/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.			SURFACE ELEV.: 15.5 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM			AGS, Inc. CONSULTING ENGINEERS		
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS	
0					SANDY CLAY (CL), dark brown, stiff, fine grained sand, root hairs, moderate plasticity						
1		1	10				16				
2		2	19		SAND (SP), yellow brown, medium dense, loose, damp	89	19				
3		3	5							CO	
4		4	10		brownish yellow		18			WA (1%)	
5		5	18		medium dense, saturated		24			WA (1%)	
6		6	25				22				
7		7	66		Increasing density dark gray, very dense						
8		8	30		dark brown, dense						
9		9	35		olive						
JOB NO. 920801.10						PROJECT: S.F. ZOO INFRASTRUCTURE M/P		SHEET 1 OF 2		PLATE A-1.19	

LOG OF BORING B - 18		DRILLING DATE: 10/28/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb falling 30 in.		SURFACE ELEV.: 15.5 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	BLOW COUNT	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION		DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
40	10	58	SAND (SP), olive grey, very dense, saturated						
			brownish yellow						
45	11	70							
50			Boring terminated at a depth of 46.5 feet on 10/28/94. Boring completed as a piezometer on 10/28/94.						
55									
60									
65									
70									
75									
80									

LOG OF BORING B - 19			DRILLING DATE: 11/04/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 34 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					ASPHALT (4 in.)					
					BASEROCK (18 in.)					
		1	13		SAND (SP), tan-brown, fine grained, medium dense, damp		1			
5		2	5		loose yellow brown		1			WA (1%)
10		3	11		dark brown, medium dense					CO
15		4	13		increasing density		14			WA (1%)
20		5	20				17			
25		6	31		medium brown, dense		14			
30		7	38							
35		8	62		dark gray, very dense, saturated					
40										
JOB NO. 920801.10						PROJECT: S.F. ZOO INFRASTRUCTURE M/P		SHEET 1 OF 2		PLATE A-1.21

2/09/95

12/09/94

LOG OF BORING B - 19			DRILLING DATE: 11/04/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb falling 30 in.		SURFACE ELEV.: 34 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	BLOW COUNT	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION			DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
40	9	36	PEAT (PT), dark gray, stiff, trace fine-grained sand, dense, wet							
			SAND (SP), dark gray, very dense, saturated, fine grained							
45	10	50 6'	olive							
50	11	22	SILTY SAND (SM), gray, medium dense, saturated, fine grained							
55	12	62	SAND WITH SILT (SP-SM), olive, very dense, saturated							
60	13	70	yellow brown							
65			Boring terminated at a depth of 61.5 feet on 11/4/94. Boring completed as a piezometer on 11/4/94.							
70										
75										
80										

LOG OF BORING B - 20			DRILLING DATE: 11/07/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 34 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0					SAND (SP), light brown, dry, loose, root hairs					
1		1	33		SAND WITH GRAVEL (SP), reddish brown, medium dense to dense, angular gravel up to 1"		3			
5		2	28		SAND (SP), yellow brown, fine grained, medium dense, damp		3			
10		3	33		medium brown, dense		18			
15		4	65		very dense		19			
20		5	21		SILT (OL), organic					
25		6	44		SAND (SP), dark brown, fine grained sand, dense, wet					
30		7	50 3"		yellow brown, very dense					
35		8	50 6"		dark brown					
40					Boring terminated at a depth of 36 feet on 11/7/94.					

LOG OF BORING B - 21			DRILLING DATE: 11/09/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Falling 1500 HAMMER TYPE: 140-lb Falling 30 in.		SURFACE ELEV.: 40 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	SAMPLE NO.	BLOW COUNT	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
0										
1		1	18		SAND (SP), yellow brown, medium dense, dry, fine grained, trace organic debris		1			
5		2	15				1			WA (1%)
10		3	25		dark brown, medium grained		16			WA (1%)
15		4	19				14			
20		5	20		yellow brown		11			
25		6	50 5"		medium brown, very dense					
30		7	79		dark brown					
35		8	50 6"		yellow brown					
40										

2/09/95

LOG OF BORING B - 21			DRILLING DATE: 11/09/94 DRILLING METHOD: Mud Rotary DRILL RIG TYPE: Failing 1500 HAMMER TYPE: 140-lb falling 30 in.		SURFACE ELEV.: 40 ft DATUM: SFCD LOGGED BY: RSY CHECKED BY: LEM		AGS, Inc. CONSULTING ENGINEERS			
DEPTH (FEET)	SAMPLE TYPE	BLOW COUNT	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION			DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	ADDITIONAL TESTS
40	9	50 5/8	SAND (SP), yellow brown, very dense, saturated <div style="text-align: right;"> 12/09/94 </div>							
45	10	72								
			Boring terminated at a depth of 46.5 feet on 11/9/94. Boring completed as a piezometer on 11/9/94.							
50										
55										
60										
65										
70										
75										
80										

UNIFIED SOIL CLASSIFICATION (ASTM D-2487-85)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND	
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS > 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS < 5% FINES	$C_u > 4$ AND $1 < C_c < 3$	GW	WELL-GRADED GRAVEL
			$C_u < 4$ AND/OR $1 > C_c > 3$	GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES > 12% FINES	FINES CLASSIFY AS ML OR CL	GM	SILTY GRAVEL
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL
	SANDS > 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SANDS < 5% FINES	$C_u > 6$ AND $1 < C_c < 3$	SW	WELL-GRADED SAND
			$C_u < 6$ AND/OR $1 > C_c > 3$	SP	POORLY-GRADED SAND
		SANDS WITH FINES > 12% FINES	FINES CLASSIFY AS ML OR CL	SM	SILTY SAND
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND
FINE-GRAINED SOILS > 50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT < 50	INORGANIC	$PI > 7$ AND PLOTS > "A" LINE	CL	LOW-PLASTICITY CLAY
			$PI > 4$ AND PLOTS < "A" LINE	ML	LOW-PLASTICITY SILT
	SILTS AND CLAYS LIQUID LIMIT > 50	INORGANIC	LL (oven dried) / LL (not dried) < 0.75	OL	ORGANIC CLAY OR SILT
			PI PLOTS > "A" LINE	CH	HIGH-PLASTICITY CLAY
		ORGANIC	PI PLOTS < "A" LINE	MH	HIGH-PLASTICITY SILT
			LL (oven dried) / LL (not dried) < 0.75	OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT

NOTE. $C_u = \frac{D_{60}}{D_{10}}$; $C_c = \frac{(D_{30})^2}{D_{10} \cdot D_{60}}$

BLOW COUNT

THE NUMBER BLOWS OF THE SAMPLING HAMMER REQUIRED TO DRIVE THE SAMPLER THE LAST 12 IN. OF AN 18 - IN. DRIVE. THE NOTATION 100/9 INDICATES 9 IN. OF PENETRATION ACHIEVED IN 100 BLOWS.

SAMPLE TYPES

- BULK SAMPLE
- PUSHED SHELBY TUBE
- STANDARD PENETRATION
- MODIFIED CALIFORNIA
- PITCHER SAMPLE
- ROCK CORE

ADDITIONAL TESTS

- CA - CHEMICAL ANALYSIS (CORROSIVITY)
- CD - CONSOLIDATED DRAINED TRIAXIAL
- CN - CONSOLIDATION
- CO - CORROSIVITY
- CU - CONSOLIDATED UNDRAINED TRIAXIAL
- DS - DIRECT SHEAR
- PM - PERMEABILITY
- PP - POCKET PENETROMETER
- RV - R-VALUE
- SA - GRAIN SIZE DISTRIBUTION
- (20) (WITH % PASSING NO. 200 SIEVE)
- SW - SWELL TEST
- TC - CYCLIC TRIAXIAL
- TV - TORVANE SHEAR
- UC - UNCONFINED COMPRESSION
- UU - UNCONSOLIDATED UNDRAINED TRIAXIAL
- WA - WASH ANALYSIS
- (20%) (WITH % PASSING NO. 200 SIEVE)
- WATER LEVEL (& DATE OF MEASUREMENT)

LEGEND TO SOIL DESCRIPTIONS

S.F. ZOO INFRASTRUCTURE MASTER PLAN

AGS, Inc.

CONSULTING ENGINEERS

PLATE A-2

WELL	GROUND SURFACE ELEVATION (FT) *	BORING DEPTH L1 (FT)	DEPTH TO BOTTOM OF CEMENT SEAL L2 (FT)	DEPTH TO TOP OF SLOTTED SECTION L3 (FT)	DEPTH TO BOTTOM OF SLOTTED SECTION L4 (FT)	O.D. (IN)	I.D. (IN)
B-2	7.4	36.5	5.5	8	35	8	2
B-4	6.1	31.5	9	10	30	8	2
B-8	18.7	26.5	4.5	5	25	8	2
B-9	20.0	31.5	4.5	5	30	8	2
B-11	18.5	31.5	8	10	30	8	2
B-16	12	40.0	9	9	39	8	2
B-18	15.5	46.5	5	5	30	8	2
B-19	32	61.5	14	15	45	8	2
B-21	41.0	46.5	15	15	45	8	2

* DATUM : SFCD

WELL DETAILS S.F. ZOO INFRASTRUCTURE MASTER PLAN		AGS, Inc. CONSULTING ENGINEERS
JOB NO.: 920801.10	DATE : 1/95	PLATE A-3

APPENDIX B

FIELD AND LABORATORY TESTING

B.1 GENERAL

Upon completion of drilling, the samples were sealed and taken to our laboratory for further examination and testing. Preliminary visual soil classifications were made in the field in accordance with ASTM D2488, Description and Identification of Soils (Visual-Manual Procedure). The soil classifications were verified by further observation of the samples in the laboratory and the testing program in accordance with ASTM D2487, Classification of Soils for Engineering Purposes.

Geotechnical field and laboratory tests were performed on selected soil samples in order to evaluate some of the engineering properties of different materials underlying the site. The tests were performed to evaluate moisture contents, dry densities, index properties, corrosivity, and R-value of soils from the site. Most tests were performed in our laboratory; however, corrosivity tests were performed by CERCO Analytical and R-value tests were performed by Construction Materials Testing.

B.2 FIELD TESTING

The SPT blow counts were used to assist in classifying the relative density of cohesionless soil deposits and the stiffness of cohesive soil deposits (Terzaghi and Peck, 1967). Blow counts are shown on the boring logs.

B.3 LABORATORY TESTING

B.3.1 Moisture and Density Tests

Moisture content and density tests were performed on selected samples to evaluate their consistencies and the moisture variation throughout the explored profile. The moisture content was evaluated in accordance with ASTM D2216, Standard Method for Laboratory Determination of Water Content of Soil, Rock, and Soil-Aggregate Mixtures, and was considered to represent the moisture content of the entire sample for dry density evaluation. The test results are presented on the boring logs.

B.3.2 Wash Analysis Tests

The fines contents of selected representative samples of the in-situ soils were evaluated by washed sieve analysis in accordance with ASTM D1140. These tests were performed on representative soil samples to aid in their identification. Results of the sieve analysis tests are shown on the boring logs.

B.3.3 Atterberg Limits Tests

Atterberg limits were evaluated to assist in the classification of a layer of cohesive soils encountered in several borings. Liquid limits and plastic limits were evaluated in accordance with ASTM D423 and D424 test procedures. The test results are shown on the boring logs.

B.3.4 R-Value Tests

R-value tests were performed on six bulk samples of the surficial soils. The tests were performed in accordance with California Test Method 301. The results of the R-value tests are presented in Appendix C and Section 3.10.

B.3.5 Corrosivity Tests

The pH, resistivity, chloride content, and sulfate and sulfide contents were determined for ten soil samples to evaluate potential soil corrosivity to buried metal and concrete. Tests were performed in accordance with ASTM test methods. The results of these corrosivity tests are presented in Appendix D and Section 2.6.

APPENDIX C

R-VALUE TEST RESULTS

CONSTRUCTION MATERIALS TESTING, INC.

Job Name: 920801.10
Sample Description: DK OL BR SD
Source: B-1, 1'-2'
Client No: Kennedy Jenks/AGS

Job No. 92441
Sample No. B-1
Date: 11/21/94
Sampled: _____ Tested: JM

R-VALUE CAL TRANS TEST 301

Specimen	A	B	C
Exudation Pressure, p.s.i.	410	265	115
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	71	68	62
% Moisture at Test	9.6	10.9	12.1
Dry Density at Test, p.c.f.	118.9	117.2	115.8
"R" Value at 300 p.s.i., Exudation Pressure	= (69)		

A	B	C

CONSTRUCTION MATERIALS TESTING, INC.

Job Name: 920801.10
Sample Description: OL BR SD
Source: B-6, 2'-3'
Client No: Kennedy Jenks/AGS

Job No. 92441
Sample No. B-6
Date: 11/21/94
Sampled: _____ Tested: JM

R-VALUE CAL TRANS TEST 301

Specimen	A	B	C
Exudation Pressure, p.s.i.	305	210	120
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	66	61	53
% Moisture at Test	13.3	14.5	16.1
Dry Density at Test, p.c.f.	115.7	114.7	112.3
"R" Value at 300 p.s.i., Exudation Pressure	= (66)		

A	B	C
= ()

CONSTRUCTION MATERIALS TESTING, INC.

Job Name: 920801.10
Sample Description: OL BR SD
Source: B-8, 2'-4'
Client No: Kennedy Jenks/AGS

Job No. 92441
Sample No. B-8
Date: 11/21/94
Sampled: _____ Tested: JM

R-VALUE CAL TRANS TEST 301

Specimen	A	B	C
Exudation Pressure, p.s.i.	310	240	110
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	74	72	68
% Moisture at Test	11.4	12.1	13.2
Dry Density at Test, p.c.f.	119.8	118.4	116.9
"R" Value at 300 p.s.i., Exudation Pressure	= (73)		

A	B	C
= ()

CONSTRUCTION MATERIALS TESTING, INC.

Job Name: 920801.10
Sample Description: YL BR SD
Source: B-9, 2'-3'
Client No: Kennedy Jenks/AGE

Job No. 32441
Sample No. B-9
Date: 11/21/94
Sampled: _____ Tested: DM

R-VALUE CAL TRANS TEST 301

Specimen	A	B	C
Exudation Pressure, p.s.i.	550	385	285
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	71	68	64
% Moisture at Test	9.0	9.7	11.2
Dry Density at Test, p.c.f.	112.1	111.4	110.2
"R" Value at 300 p.s.i., Exudation Pressure	= (66)		

A	B	C

CONSTRUCTION MATERIALS TESTING, INC.

Job Name: 920801.10
Sample Description: YL BR SD W/GR
Source: B-13, 2'-4'
Client No: Kennedy Jenks/AGS

Job No. 92441
Sample No. B-13
Date: 11/21/94
Sampled: _____ Tested: JM

R-VALUE CAL TRANS TEST 301

Specimen	A	B	C
Exudation Pressure, p.s.i.	470	275	190
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	74	70	68
% Moisture at Test	9.8	10.7	11.2
Dry Density at Test, p.c.f.	124.3	122.9	122.4
"R" Value at 300 p.s.i., Exudation Pressure	= (71)		

A	B	C
= ()

CONSTRUCTION MATERIALS TESTING, INC.

Job Name: 920801.10
Sample Description: OL BR SD
Source: B-17, 2'-3'
Client No: Kennedy Jenks/AGS

Job No. 92441
Sample No. B-17
Date: 11/21/94
Sampled: _____ Tested: OK

R-VALUE CAL TRANS TEST 301

Specimen	A	B	C
Exudation Pressure, p.s.i.	440	325	195
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	67	64	56
% Moisture at Test	12.2	13.5	14.1
Dry Density at Test, p.c.f.	111.2	110.5	108.7
"R" Value at 300 p.s.i., Exudation Pressure	= 62		

A	B	C

APPENDIX D

CORROSIVITY TEST RESULTS

CERCO ANALYTICAL

31909 Hayman Street • Hayward, CA 94544 • (510) 487-9675 • Fax (510) 471-3698

December 7, 1994

Job No.9411087
Cust.No.10563

Mr. Luis Moura, G.E.
AGS, Inc.
120 Howard St., Ste 600
San Francisco, CA 94105

SUBJECT: Project No.920801.10
S.F. Zoo Infrastructure
Soil Corrosivity Analysis
ASTM Test Methods

Dear Mr. Moura::

In accordance with your request, we have analyzed the soil samples furnished by your office and have evaluated them for corrosivity using ASTM Test Methods. The results are enclosed.

Based upon the resistivity measurements, Soil Samples No.001, 002, 003, 004, 005, 008 and 010 are classified as "moderately corrosive". Samples No.006 and 009 are classified as "mildly corrosive" and Sample No.007 is classified as "negligibly corrosive." All buried iron steel, cast iron, ductile iron, galvanized steel and dielectric coated steel or iron should be properly protected against corrosion depending on the critical nature of the structure.

The chloride ion concentration ranges from non-detectable to 43-ppm. Because the chloride ion concentration is less than 300-ppm, it is determined to be insufficient to attack steel embedded in a concrete mortar coating.

The sulfate ion concentration was non-detectable for all samples and is, therefore, determined to be insufficient to damage a cement mortar.

The sulfide ion concentration is also non-detectable at all locations.

We appreciate the opportunity of working with you on this project. If you have any questions, or if you require additional information, please do not hesitate to contact us.

Very truly yours,
CERCO ANALYTICAL

J. Darby Howard, Jr., P.E.
President

JDH/jdl

CERCO ANALYTICAL

31909 Hayman Street • Hayward, CA 94541 • (510) 487-9675 • Fax (510) 471-3698

Mr. Luis Moura, G.E.
AGS, Inc.
120 Howard St., Ste 600
San Francisco, CA 94105

Client Job No. 920801.10
Client Project Name: S.F. Zoo Infrastructure
Date Sampled: Not Indicated
Date Received: 11/18/94
Matrix: Soil

December 7, 1994
Job No. 9411087
Sample No. 001-010
Cust. No. 10563

Lab No.	Client I.D.	pH	Sulfate mg/kg	Specific Conductivity umho/cm	Sulfide mg/kg	Chloride mg/kg
001	Boring No.2-1	7.5	N.D.	380	N.D.	41
002	Boring No.2-4	7.7	N.D.	260	N.D.	26
003	Boring No.3-1	6.7	N.D.	150	N.D.	1
004	Boring No.6-3	7.9	N.D.	240	N.D.	32
005	Boring No.8-1	7.6	N.D.	170	N.D.	28
006	Boring No.8-4	8.0	N.D.	90	N.D.	13
007	Boring No.13-2	8.1	N.D.	20	N.D.	N.D.
008	Boring No.14-2	7.4	N.D.	190	N.D.	37
009	Boring No.18-3	7.7	N.D.	70	N.D.	43
010	Boring No.19-3	8.2	N.D.	140	N.D.	14

Detection Limit	----	60	10	10	5
Method No.:	D2976	D1164	D1125	SM4500	D512B
Date Analyzed:	11/29/94	11/29/94	11/29/94	11/29/94	11/28/94

N.D. = Not Detected

Reid Combs
Laboratory Director

Quality Control Summary

All laboratory quality control parameters were found to be within established limits.

CERCO ANALYTICAL

31909 Hayman Street • Hayward, CA 94544 • (510) 487-9675 • Fax (510) 471-3698

Mr. Luis Moura, G.E.
AGS, Inc.
120 Howard St., Ste 600
San Francisco, CA 94105

Client Job No. 920801.10
Project Name: S.F. Zoo Infrastructure
Matrix: Soil
Date Sampled: Not Indicated
Date Received: 11/18/94

December 7, 1994
Job No. 9411087
Sample No. 001-010
Cust. No. 10563

Lab No.	Client I.D.	Resistivity* ohm-cm	
001	Boring No.2-1	2,630	Moderately Corrosive
002	Boring No.2-4	3,850	Moderately Corrosive
003	Boring No.3-1	6,670	Moderately Corrosive
004	Boring No.6-3	4,170	Moderately Corrosive
005	Boring No.8-1	5,880	Moderately Corrosive
006	Boring No.8-4	11,110	Mildly Corrosive
007	Boring No.13-2	50,000	Negligible
008	Boring No.14-2	5,260	Moderately Corrosive
009	Boring No.18-3	14,290	Mildly Corrosive
010	Boring No.19-3	7,140	Moderately Corrosive

Detection Limit: ----
Method No.: ----
Date Analyzed: 12/07/94

* Calculated Resistivity

APPENDIX E

LIQUEFACTION POTENTIAL AND
SEISMIC SETTLEMENT EVALUATION

E.1 LIQUEFACTION POTENTIAL

Appendix E presents the results of our liquefaction potential and liquefaction-induced settlement evaluation for the San Francisco Zoo Infrastructure Master Plan. The liquefaction potential and settlement evaluations were made for the MCE based on the results of our field exploration program and blow counts recorded for driving the California Modified and SPT samplers. Our evaluations were made using the procedure developed by Seed and others (1984) based on liquefaction and seismic settlement observation in previous earthquakes.

A comprehensive collection of site conditions at various locations where some evidence of liquefaction was known to have or to have not taken place was collected by Seed and others (1984). These data on sandy soils with a fines content less than 5 percent under magnitude 7-1/2 earthquake conditions can be presented as relationships between field values of average cyclic stress ratio, τ_{av}/σ'_o (where: τ_{av} = average horizontal shear stress induced by an earthquake; and σ'_o = initial effective overburden pressure on the soil element), and the SPT blow counts corrected for certain effects; Plate E-1 presents the data collected by Seed and others (1984). For a given seismic shaking condition and a sandy deposit, a value of the average cyclic stress ratio and the corrected SPT values can be calculated. If the data point corresponding to the average cyclic stress ratio and the corrected SPT value for the sand deposit lies above the line shown on Plate E-1, the site is potentially vulnerable to significant strength loss and liquefaction under the speculated shaking conditions; otherwise, it is considered likely to be stable.

In using Plate E-1 for liquefaction potential evaluation, the measured Standard Penetration Test (SPT) blow counts should be corrected for various factors using the method proposed by Seed and others (1984). The raw SPT blow count, N , is corrected to obtain the

modified penetration resistance, $(N_1)_{60}$. This modified penetration resistance is computed as follows:

$$(N_1)_{60} = N \cdot \frac{ER}{60} \cdot C_n \cdot C_z \cdot C_s \quad (E.1)$$

where:

N: raw SPT blow count (blows/ft)

C_n : a factor that depends on the effective overburden pressure at the depth where the penetration test was conducted, as shown on Plate E-2.

C_z : a factor that depends on the length of the drive rods; the following C_z factors may be used for various depths:

<u>Depth</u>	<u>C_z</u>
<10 ft	0.75
>10 ft	1.00

C_s : a factor that depends on the sampling tube; for a split-spoon sampler without liner (ID = 1.5" and OD = 2.0"), the following C_s factors may be used:

<u>Raw Blow Count, N</u>	<u>C_s</u>
≤ 10	1.0
> 10	1.2

ER: energy ratio expressed as percent of theoretical free-fall energy delivered to the drill stems in performing SPT, which for the USA is essentially as follows when the SPT is performed with two wraps of rope around the pulley:

<u>Hammer</u>	<u>ER</u>
Safety	60%
Donut	45%

The average cyclic stress ratio, τ_{av}/σ'_o , at a depth can be estimated from dynamic site response analyses; it also can be estimated with reasonable accuracy from the following equation as discussed by Seed and Idriss (1982).

$$\tau_{av}/\sigma'_o = 0.65 \cdot \frac{a_{max}}{g} \cdot \frac{\sigma_o}{\sigma'_o} \cdot r_d \quad (E.2)$$

where:

a_{max} : maximum acceleration at the ground surface

σ_o : total overburden pressure on sand element

σ'_o : effective overburden pressure on sand layer

r_d : a stress reduction factor varying from a value of one at the ground surface to an average value of 0.9 at a depth of about 30 feet, as shown on Plate E-3.

The effects of fines content can be incorporated in the evaluation to some extent by using the data presented on Plate E-4, which is similar to Plate E-1. However, Plate E-4 shows

the liquefaction/no-liquefaction boundaries for soils with 15 and 35 percent fines content in addition to that for soils with less than 5 percent fines content.

As shown on Plate E-5, another correction factor, $\delta(N_1)_{60}$, should be added to $(N_1)_{60}$ to account for fine contents as follows:

$$(N_1)_{60 \text{ Fine}} = (N_1)_{60} + \delta(N_1)_{60} \quad (\text{E.3})$$

The variations of the correction factor for fines contents as a function of fines content and blow counts are presented on Plate E-5. The data shown on Plate E-5 were used in correcting blow counts used in this study. In addition, it should be noted that to convert Modified California sampler blow counts to SPT blow counts, the Modified California sampler blow counts were divided by a correction factor of 1.5.

Recorded blow counts and corrected N-values for sands are summarized in Table E-1. Using Equations E.1 and E.2 and Plate E-1, corrected N-values for various depths resulting in liquefaction for the subject site were evaluated and the results are presented on Plate E-6 for the MCE. As Plate E-6 indicates, liquefaction is anticipated to occur only in 8 of the 21 borings drilled for this study. It should be noted that only blow counts on loose to medium dense sands at or below the groundwater level were used in liquefaction potential evaluation for this study. Blow counts in sands above the groundwater level or in dense sands below the groundwater level were not included in our analyses as can be seen from Table E-1. Additional discussion is presented in Section 3.2.5.1.

TABLE E-1
STANDARD PENETRATION TEST DATA

Boring No.	Depth (ft)	Soil Type	Percent Fines	Sample Type	N (SPT)	C_u	C_c	C_e	$(N_1)_{en}$	$\bar{\sigma}(N_1)_{en}$	$(N_1)_{en}$
B-1	6	SP	1.2	SPT	11	1.65	0.75	1.2	16	0	16
B-1	11	SP	1.8	SPT	16	1.37	1.00	1.2	26	0	26
B-2	11	SP	1.8	SPT	22	1.35	1.00	1.2	36	0	36
B-7	6	SP	1.0	SPT	12	1.65	0.75	1.2	18	0	18
B-7	16	SP/ML	10-20	SPT	12	1.20	1.00	1.2	17	4	21
B-4	6	SP	1.1	SPT	12	1.65	0.75	1.2	18	0	18
B-13	16	SP	< 5	SPT	13	1.07	1.00	1.2	17	0	17
B-14	21	SP	2.8	SPT	15	0.99	1.00	1.2	18	0	18
B-15	4	SP	< 5	SPT	15	1.85	0.75	1.2	25	0	25
B-15	6	SP	13.2	SPT	15	1.66	0.75	1.2	22	4	26
B-16	11	SW	1.5	SPT	16	1.28	1.00	1.2	25	0	25
B-17	16	SP	< 5	SPT	13	1.11	1.00	1.2	17	0	17
B-18	16	SP	0.7	SPT	18	1.11	1.00	1.2	24	0	

E.2 SEISMICALLY-INDUCED SETTLEMENT

Tokimatsu and Seed (1987) presented simplified methods of analysis for estimating volume changes and probable settlements of either saturated or unsaturated sand deposits subjected to earthquake shaking. Tokimatsu and Seed (1987) estimated volumetric strain of liquefied sandy soils based on the performance of liquefied sites in previous earthquakes. Based on the results presented on Plate E-6, it is estimated that the liquefiable soils at the site could experience up to two percent volumetric strain, which is approximately equivalent to vertical strain. Volume changes will also occur in unsaturated sandy soils above the groundwater level subjected to earthquake shaking as a result of densification. Based on the estimated thickness of the soil zone which can experience seismically-induced settlement, which would range up to 20 feet in six of the borings, the

estimated seismically-induced settlement at the site would range from about 0 up to 6 inches. Table E-2 shows the total estimated seismically-induced settlements resulting from liquefaction of saturated sands and densification of unsaturated sands, at each boring.

TABLE E-2
ESTIMATED SEISMICALLY- INDUCED SETTLEMENT

Boring Number	Thickness of Soils Subject to Seismically-Induced Settlement (ft)	Estimated Seismically- Induced Settlement* of Ground Surface (in.)
B-1	10	1
B-2	3	½
B-3	15	3
B-4	7	1
B-5	7	1
B-6	7	3
B-7	6	2
B-8	8	4
B-9	5	1
B-10	5	2
B-11	0	0
B-12	12	3
B-13	12	3
B-14	10	5
B-15	7	1
B-16	12	5
B-17	15	4
B-18	16	6
B-19	16	6
B-20	0	0
B-21	6	1

* Resulting from liquefaction of saturated sands and densification of unsaturated sands. Seismically-induced settlement from liquefaction estimated by multiplying the average percent volumetric strain from Plate E-6 (about 1.5%) by the thickness of potentially liquefiable soils; values shown were rounded.

ADAPTED FROM SEED AND OTHERS (1984)

FIELD LIQUEFACTION
DATA FOR SANDS
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE E - 1

ADAPTED FROM SEED AND IDRISS (1982)

SPT CORRECTION FACTORS
FOR OVERBURDEN PRESSURES
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE E - 2

$$r_d = \frac{(\tau_{max})_d}{(\tau_{max})_s}$$

ADAPTED FROM SEED AND IDRISS (1982)

CORRECTION FACTOR FOR EVALUATION
OF CYCLIC STRESS RATIO
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE E - 3

ADAPTED FROM SEED AND OTHERS (1984)

FIELD LIQUEFACTION DATA
FOR SANDY SOIL
SAN FRANCISCO ZOO
INFRASTRUCTURE MASTER PLAN

AGS, Inc.
CONSULTING ENGINEERS

JOB NO.: 920801

DATE : 1/95

PLATE E - 4

at base
TAB 5
2