State of California   Business, Transportation
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Memorandum

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To: MR. MEHI NABIZADEH – 11
Project Engineer

Date: June 17, 2002

File: 11-IMP-111-
KP R28.2/R32.5
EA-11-167871

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
Geotechnical Services
Office of Geotechnical Design - South

Subject: State Route 111, Brawly Bypass (Stage 1): Geotechnical Design Report.

In accordance with your request, enclosed is the Geotechnical Design Report (GDR) for State Route 111, Brawley Bypass (Stage 1) in Imperial County near the City of Brawley. The report includes the results of our field investigation, laboratory test results, and engineering analysis. The geotechnical data developed were used to detail factors that will influence project design and construction.

Should you have any questions, please contact me at (858) 467-3290.

Prepared by: Date:

Michael M. Fordham 6/17/02

Mike Fordham, P.E.
Transportation Engineer
Office of Geotechnical Design - South

cc: James Chai
Joe Egan
(RGES 02)

CALIFORNIA DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL DESIGN REPORT

Construct Highway in Imperial County Near Brawley on route 78 form 0.5 km East to 1.2 km East of East Junction Route 111 and on Route 111 from 0.2 km North of Mead Road to 0.9 km North of Route 78

11-IMP-78/111
KP 24.6/25.4, R32.7/R36.0
11-167871

Prepared for:

Caltrans
District 11

By:

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1. INTRODUCTION

The proposed project consists of upgrading State Route 111 (SR-111) in Imperial County from a two lane conventional highway to a four lane divided expressway, located between Mead Road near the City of Brawly, and the intersection with State Route 78/86 (SR-78/86) to the north east of the City of Brawley (Figure 1 – Vicinity Map). The proposed project consists of three stages, which are designed to relieve traffic on SR-78 through the City of Brawley (Figure 1 – Project Map). This report pertains to Stage 1 of the proposed project, which extends from 0.2 km north of Mead Road (KP R32.7) to 0.9 km north of State Route 78 (SR-78) (KP R36.0).

Stage 1 of the proposed project consists of construction of two-lane north and southbound roadbeds. Also included in the project are improvements to the intersection with SR-78 and construction of additional frontage roads and cul-de-sacs, as well as a connector road to old SR-111. The investigation phase of the Geotechnical Design Report (GDR) was comprised of review of published data, site reconnaissance, subsurface exploration by drilling, in-situ testing by standard penetration tests (SPT's) and cone penetrometer tests (CPT's), and Geotechnical laboratory testing.

The purpose of this GDR is to reveal the subsurface geotechnical conditions, provide analysis of anticipated site conditions as they pertain to the project described herein, and to recommend design and construction criteria for the roadway portion of the proposed project. This GDR also establishes a geotechnical baseline for assessing changing site conditions that may be claimed.

2. EXISTING FACILITIES AND PROPOSED IMPROVEMENTS

The Stage 1 project alignment is proposed as an embankment section along its entire length. The road surface elevation along the proposed new alignment of the State Route 111 (SR-111) is to reach a maximum height of approximately 2.0 m above the existing ground surface, including the roadway structural section. The preliminary design plans for the proposed project have a planned structural section of 1.2 m in thickness. Due to the loose nature of the subgrade soils 0.9 m of subexcavation and recompaction is planned for the soils under the traveled way.

Existing SR-111 intersects State Route 78(SR-78) within the project limits. The proposed new highway alignment will also intersect SR-78. The intersection will be an at grade intersection. SR-78 will be reconstructed from 0.5 km to 1.2 km east of the junction with the existing SR-111 and SR-78 intersection. Within that area, SR-78 will be widened from 2 to 4 lanes. The proposed roadway is planned as an embankment section with its grade varying from 0 to 2 m above the existing ground elevation, including the structural section. The new structural section at the intersection with SR-111 will be 1.2 m thick. The widened sections of existing SR-78 will match the existing structural section of SR-78, which is 294 mm thick. Existing SR-111 is a two lane conventional highway with 3.6 m wide lanes and 1.2 m wide paved shoulders without dikes

Existing land along the proposed project corridor is primarily used for agricultural purposes and is irrigated and drained using a network of subsurface tile drains and a series of open concrete lined and unlined canals and drains operated by the Imperial Irrigation District (I.I.D). These drainage improvments cross under the existing highway at many locations by means of culverts with associated headwalls, endwalls, or ditch excavations.

The main lanes for proposed SR-111 will be comprised of 7.2 m wide traveled way in both directions with a 1.5 m inside and a 3.0 m outside shoulders. The outside embankment slope will have a slope ratio of 1:4 or flatter (vertical to horizontal), and inside median slope will be constructed with a relatively shallow slope. SR-78 will be comprised of 7.2 m traveled way in both directions with 2.4-m shoulder, and a slope ratio of 1:2 or flatter. The main lanes of SR-111will be based the "G" baseline, which extends from station 340+00 (0.2 km north of Mead Road) to station 372+60 (0.9 km north of SR-78). The main lanes of SR-78 will be based on the "P" baseline, which extends from station 255+65 (0.5 km east of SR-111) to station 263+08 (1.2 km east of SR-111). Proposed frontage roads and cul-de-sacs will consist of the following:

- Frontage road and cul-de-sac (station 0+00 to 3+59 "C" baseline) at intersection of existing SR-111 (station 348+39.509 "E" baseline) to intersection with proposed SR-111 (station 346+80 "G" baseline)
- Frontage road south to Mead Road east of proposed main alignment from "C" baseline (station 13+00 to station 18+38.137 "GFR" baseline)
- Frontage Road along north and south side of SR-78 widening (approximate station 260+00 to station 263+50 "P" baseline)

3. PERTINENT REPORTS AND INVESTIGATIONS

1. Materials Design Report, 11-IMP-111, KP R32.7/R36.0, *in progress*, by California Department of Transpiration; District 11, Pavement Engineering Section.

2. Materials Design Report, 11-IMP-111, KP R28.2/R32.5, by California Department of Transpiration; District 11, Pavement Engineering Section.

3. Preliminary Geotechnical Report, 11-IMP-78/111, KP L11.6/L25.3 & 33.5/39.7, by California Department of Transportation; Office of Geotechnical Design South Branch, June 1998.

4. Geotechnical Design Report, 11-IMP-111, KP R28.2/R32.5, by California Department of Transportation; Office of Geotechnical Design South Branch, March 2001.

5. Preliminary Engineering Geology and Geologic hazards Report, July 1992, By California Department of Transportation District 11 Materials Laboratory.

6. Laboratory Testing Report, Brawley Bypass Imperial County, California, June 2002, By GEOCON, Geotechnical and Environmental Consultants

4. PHYSICAL SETTING

4.1 Topography and Climate

The Imperial Valley is a broad, flat lying expanse with little topographic relief and contains the Salton Sea, a base level sink that lies below sea level. The region's natural ground surface was formed as a lake floor and is therefore relatively flat with gentle northward dip towards the Salton Sea. The Imperial Valley receives very little precipitation annually resulting in an extremely arid desert climate.

4.2 Man-Made and Natural Features of Engineering and Construction Significance

Agricultural water supply canals and farm field drains cross the area. Tile drains criss-cross the agricultural fields about 1.5 m below the ground surface. Locations of field drains are on file at the Imperial Irrigation District Office.
An underground gas line operated by the Southern California Gas Company parallels the east side of the existing SR-111 within the state right-of-way.

4.3 Regional Geology

The project corridor lies within the Colorado Desert geomorphic province. One of the most significant geologic features of that province is the Salton Trough, which is an inland extension of the Gulf of California. That was sealed off by the Colorado River delta sediment.

In the past, Colorado River sediments were deposited within an inland lake. A former shoreline of one such antecedent lake, known as Lake Coahuilla, is evident at about sea level, outside of the project limits. Lake Coahuilla occupied this trough periodically for thousands of years depositing at least 30 m of Quaternary lakebed sediments. These lake sediments are unconsolidated and comprised mostly of clay, silt, and fine to very fine-grained sand.

The project area is comprises the surface sediments that have been disturbed and/or reworked by extensive farming operations. Most near surface sediments along the proposed roadway are loose deeply tilled soils that can be rich in organic content. Fill material, used to elevate land for either irrigation channels or for farm fields, is also present

4.4 Soil Survey Mapping

The Soil Survey of Imperial County California, Imperial Valley Area By the USDA Soil Conservation Service, 1981 was used to map soils encountered along the project corridor. Shown on Table 4.1 are the soil units encountered along the project corridor with a summary of their engineering properties. The Soil Survey only maps surface soils to a depth of 1.5 m.

In addition to those values presented in Table 4.1, all soil types exhibit a high risk of corrosion to uncoated steel and a moderate to high risk of corrosion to concrete. The soils in the area also exhibit low permeability that range from 1.52 to 15.2 mm/hour according to the Soil Survey of Imperial County California, Imperial Valley Area.

Table 4.1 – Soil Parameter from SCS Soil Survey Mapping

Soil map Symbol	Soil Name	Depth (meters)	USCS Classification	Percent Fines (<No. 200 sieve)	Liquid Limit	Plasticity Index	Soil pH	Depth to Water (meters)	Shrink –Swell Potential
110	Holtville silty clay, wet	0-0.4 0.4-0.6 0.6-0.9 0.9-1.5	CH-CL CH-CL ML SM,ML	85-95 85-95 55-85 20-55	40-65 40-65 25-35 -	25-35 25-35 NP-10 NP	7.4-8.4 7.4-8.4 7.4-8.4 7.4-8.4	0.9-1.5 (perched)	High High
114	Imperial silty clay, wet	0-0.3 0.3-1.5	CH CH	85-95 85-95	50-70 50-70	25-45 25-45	7.9-8.4 7.9-8.4	0.9-1.5 (perched)	High High
115	Imperial Glenbar silty clay loams	0-0.3 0.3-1.5	CL CH	85-95 85-95	40-50 50-70	10-20 25-45	7.9-8.4 7.9-8.4	0.9-1.5 (perched)	High High
122	Meloland very fine sandy loam	0-0.3 0.3-0.7 0.7-1.8	ML ML CH,CL	55-85 50-70 85-95	25-35 25-35 40-65	NP-10 NP-10 20-40	7.4-8.4 7.4-8.4 7.4-8.4	0.6-0.9 (perched)	Low Low High

5. LABORATORY GEOTECHNICAL SOILS TESTING

Laboratory soils testing was performed on undisturbed samples. Testing, by Geocon consultants was in order to determine in-situ moisture, density, gradation, Atterberg Limits, specific gravity and consolidation characteristics of the soils. The testing program and a summary of laboratory test results are presented in the Appendix C (Table I-V).

6. PROJECT SITE GEOTECHNICAL CONDITIONS

6.1 Project Site Geology

Quaternary (DMG, 1962) lacustrine sediments exist along the entire length of the project corridor, according to geologic mapping presented in Figure 6.1. The lacustrine (lake bed) deposits were derived from the historical Lake Cahuilla. These materials were generally comprised of poorly graded fine sands, silty sands, sandy silts, silts, lean clays and fat clays.

6.2 Subsurface Soil Conditions

The proposed project area consists of lakebed deposits. These deposits are composed of sands, silts, and clays. Based on subsurface exploration, soils above approximate elevation of 54.2 m below mean sea level consist primarily of silty clays and clays. Based on Standard Penetration Tests the clay has a firm to stiff consistency. Fat clays were encountered during our subsurface investigation, and will likely be present within the roadway embankment and subgrade. However due to the hydrologic regime that exists in the area and due to agricultural practices the variation in subsurface moisture content that are often the cause of pavement distress are not expected.

Sands and silts were encountered at a approximate elevation of 54.2 m below mean sea level and thin seams interspersed within the clay layers. The sands found within the proposed project site are typically fine grained, poorly graded, and loose to medium dense. The sands at depth have similar relative density based on the Standard Penetration Tests as layers that are closer to the surface. The sand layers were found to be moist to wet. The low relative density and the saturated nature of the sands in combination with a high degree of siesmicity in the area could potentially result in the occurrence of localized liquefaction within the project area.

6.3 Water

Surface runoff along the project alignment is by sheet flow into soil lined ditches located at the toe of slope. These ditches empty into irrigation drainage ditches, which in turn empty into the Alamo River or New River.

Four observation wells were installed to the final depth of borings. Groundwater was encountered at all four observation wells. Based on the elevation of the perched groundwater encountered, water is not expected to significantly affect the proposed project, except at the location of Observation Well P-3, where the depth of the perched water table is located at an elevation of 58.7 m below sea level. The approximate location, ground surface elevation, and the groundwater elevation at each well can be found in Table 6.1. The groundwater elevations along the roadway alignment ranged from 57.6 m to 62.m below see level. Though only the upper 1-meter of existing soil is to be disturbed, the possibility of encountering groundwater or highly saturated clayey soils should be anticipated at the approximate location of Observation Well P-3. The fluctuation of groundwater elevations is possible throughout the year due to changes in irrigation practices and precipitation.

Table 6.1 – Ground Water Conditions

Boring No.	Approximate Location along "G" Line	Approximate Ground Surface Elevation	Perched Ground Water Elevation (Measured 4/15/2002)
111-1-B2 (P1)	324+04, 0.89 Lt	63.8	62.0
111-1-B3 (P2)	355+34, 0.95 Rt	61.4	60.1
111-1-B4 (P3)	364+68, 47.0 Rt	60.8	58.7
111-1-B5 (P4).	373+04, 0.02 Rt	59.2	57.6

6.4 Project Site Seismic Conditions

The Salton Trough is an active spreading center, a tectonic basin formed by faulting and rifting of tectonic plates. Two separate basins the Salton Sea and the Mesquite basin were formed as a result of the two tectonic plates slowly drifting apart. A series of right lateral en echelon faults are present due to the rifting process. The overall trend of these faults is northwesterly (Figure 6.2 - Regional Fault Map). The active fault closest to the project site is the Imperial Fault. The Imperial Fault crosses State Route 111 approximately 12.8 km (KP 19.2) south of Mead Road. Three other major active faults lie within approximately 20 km of the project limits. They are 1) Brawley Seismic Zone 2) The Superstition Hills Fault 3) The Superstition Mountains Fault. These active faults have caused damage to roadways in the area in the past. The Imperial Fault does not cross the proposed Stage 1 alignment, though it has been chosen as the controlling fault due to its proximity to the project site. Table 6.2 summarizes the names of the known active faults, their distance from the project site, and the Maximum Credible Earthquake Magnitudes for all faults within 100 km of the project site.

Table 6.2 – Deterministic Site Parameters (from Thomas Blake's EQFAULT software 1996 and from CDMG open file report (OFR 92-1)

Fault Name	**Approximate Distance (km)**	**Maximum Credible Earthquake Magnitude**
Borrego Mountain (San Jacinto)	46	6.5
Casa Loma-Clark (San Jacinto)	71	7.0
Coyote Creek (San Jacinto)	75	7.0
Elsinore	46	7.5
Hot S-Buck Rdg. (San Jacinto)	93	7.0
Imperial – Brawley	4	7.0
San Andreas (Coachella Valley)	54	8.0
Sand Hills	30	8.0
Superstition Hills (San Jacinto)	9	7.0
Superstition Mtn. (San Jacinto)	13	7.0

7. GEOTECHNICAL ANALYSIS AND DESIGN

7.1 Dynamic Analysis

The design ground motion parameters recommended for the project are summarized below:

Controlling Fault:	Imperial Fault
Maximum Credible Event Magnitude:	7.0
Maximum Probable Event Magnitude	7.0
Peak Horizontal Ground Acceleration	0.54g (EQFAULT)
Peak Horizontal Ground Acceleration	0.60g (Mualchin)
Repeatable Horizontal Ground Acceleration	0.35g (EQFAULT)
Probability of Maximum Probable Event	0.012/year

The EQFAULT software program by Thomas Blake, 1992, was used to calculate the Maximum Credible Earthquake and the Peak Horizontal Ground Acceleration along with the California Seismic Hazard map created for the California Department of Transportation by Lilliana Mualchin, 1995. The Maximum Credible Earthquake and Peak Ground Acceleration were calculated for all faults that are within 100 km of the project site. EQFAULT uses the ground motion attenuation relations of Campbell and Bozorgnia, 1994, for soft rock to determine ground acceleration and maximum credible earthquake.

7.1.1 Liquefaction and Earthquake Induced Settlement Analysis

The evaluation of the liquefaction potential of the subsurface soils is based on the consideration of the anticipated groundwater levels, soil types, soil gradation, relative soil density, the intensity of ground shaking, and the duration of the shaking. In general, liquefaction potential is greatest for loose, fine sands and decreases with increasing grain size and clay and gravel content.

Lakebed deposits underlie the project site. These deposits consist of sands, silts, and clays. Due to agricultural irrigation practices within the Imperial Valley a perched water table exists. This perched water table lies at approximately 2 m below the existing ground surface within the project limits. During our subsurface investigation layers of potentially liquefiable fine sand were encountered at depths ranging from 4.5 to 7.5 m below the ground surface. These soils typically exist in a loose to medium dense state. There is a possibility that these layers could liquefy during a strong seismic event, resulting in distortions of the roadway embankment. A further liquefaction evaluation was determined to be unwarranted since no structures are to be supported on these layers.

The use of extreme liquefaction mitigation measurements is probably unwarranted due to their high cost. If damage occurrs to the roadway due to liquefaction induced differential settlement of the embankment the rebuilding of damaged roadways is rapid and more economical than mitigation of the potential liquefaction at the time of constrction.

7.2 Cuts and Excavations

Based on our review of the preliminary project plan and profile drawings, the only permanent cuts for the proposed improvements are for toe of slope ditches, less than 1 meter in depth. The proposed improvements will require relatively minor temporary sub-excavation of the roadway. The proposed excavations are anticipated to expose loose, moist soils that have been disturbed by agricultural practices.

Temporary shallow excavations up to 1.5 meters in depth should be generally stable, except in clean sandy material. In order to satisfy OSHA requirements, excavations that are deeper than 1.5 meters, and which will be entered by workers, should be shored or the side slopes laid back at an inclination of 1:1.5 (vertical: horizontal) or flatter.

Topsoil, vegetation, pavement, and other deleterious materials should be removed from the cut areas prior to the excavation operation. The total depths and limits of clearing should be performed in accordance with Section 16 of the Caltrans Standard Specifications. Permanent cut slopes should not have a finish inclination steeper that 1:2 (vertical: horizontal).

Excavation of on-site materials may be performed utilizing conventional heavy-duty earthmoving equipment.

7.2.1 Grading Factor

District 11 Pavement Engineering Section is currently determining the grading factor for this project.

7.3 Embankments

The preliminary project profiles indicate that the maximum embankment fill height will be approximately 2.5 m including the structural section. The side slopes are to be constructed at a 1:2 (vertical to horizontal) or flatter slope. No major cuts are proposed for this project. Due to the lack of roadway excavation proposed for this project it is expected that the majority of the embankment will be constructed with material from offsite borrow sources. The placement and compaction of the embankment fill should conform to Sections 19-5 and 19-6 of the Caltrans Standard Specifications. All embankment slopes should be constructed at an inclination no greater that 1:2 (vertical to horizontal). The embankment slopes should be protected from erosion in accordance with Section 20 of the Caltrans Standard Specifications.

7.3.1 Embankment Foundations

Minor Settlement of the embankment and the subgrade soils on the order of 40 mm or less is expected following placement of fills and structural section. Overconsolidated clays underlie the proposed project site. The clays were determined to be overconsolodation based on consolidation laboratory consolidation tests performed on several of the samples. The majority of settlement is expected to occur during construction, thus a waiting period is not warranted.

8. CONSTRUCTION CONSIDERATIONS

8.1 Construction Advisories and Construction Considerations that Influence Design/Specifications

The upper 1.0 m thick layer of soil along the project site has a soft/loose consistency due to agricultural practices. Within the road bed prism the soil shall be removed and recompacted in accordance with the recommendations made in the "District 11-Materials Design Report, October 31, 2001".

Perched groundwater will likely be encountered in excavation at an approximate elevation of 57.6 to 62.0 m below mean sea level.

Due to the clayey nature of the surface soil water percolation rates are expected to be slow

8.2 Differing Site Conditions

Differing site conditions are conditions that were not encountered during the site investigation, or are latent physical conditions that differ materially from those indicated within this Geotechnical Design report. It is imperative that the designers, the resident engineer, and/or the contractor notify the geotechnical staff of the Office of Geotechnical Design-South immediately upon recognition of any condition differing from that described within this report. Office of Geotechnical Design-South can be reached by calling Joe Egan at (858) 467-4051 or Mike Fordham at (858) 467-3290.