NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH

State University of New York at Buffalo

PB95-252326

Pipeline Replacement Feasibility Study: A Methodology for Minimizing Seismic and Corrosion Risks to Underground Natural Gas Pipelines

by

R.T. Eguchi, H.A. Seligson and D.G. Honegger

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18101 Von Karman Avenue, Suite 400
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Technical Report NCEER-95-0005

March 2, 1995

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R.T. Eguchi[1], H.A. Seligson[2] and D.G. Honegger[3]

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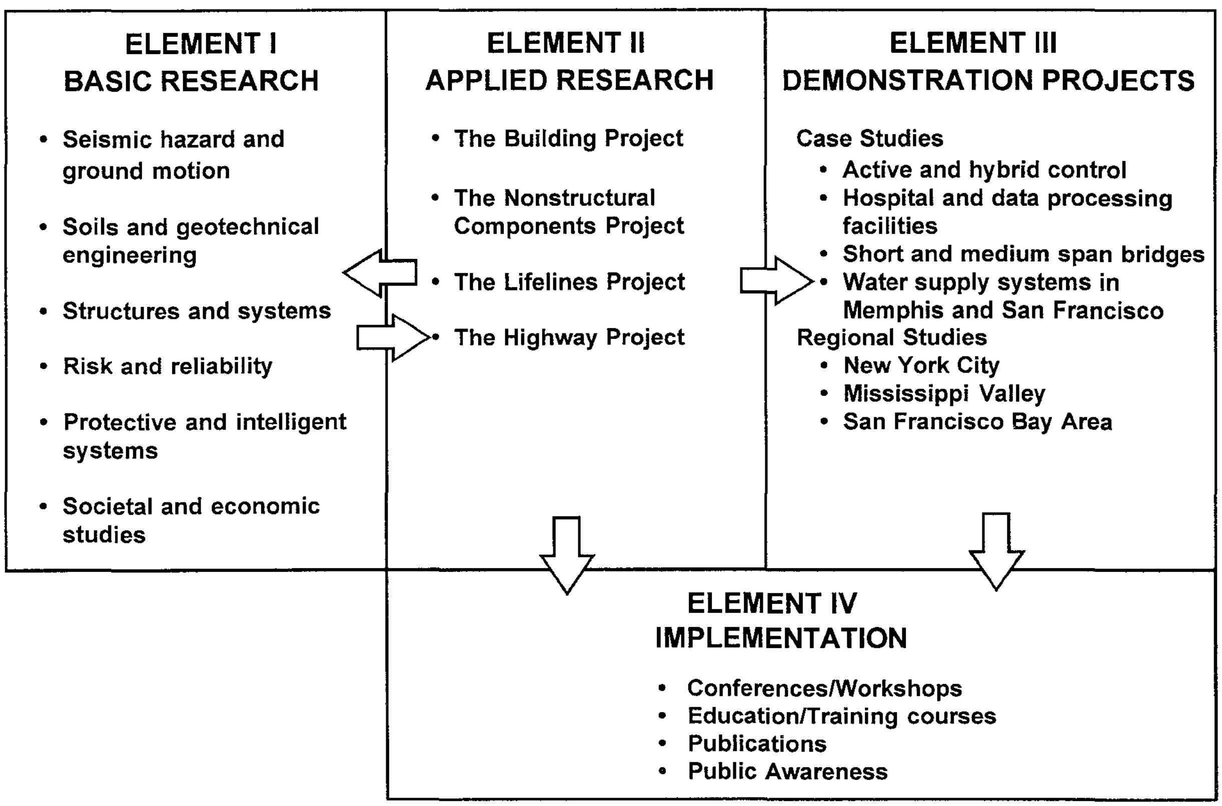
PREFACE

The National Center for Earthquake Engineering Research (NCEER) was established to expand and disseminate knowledge about earthquakes, improve earthquake-resistant design, and implement seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis is on structures in the eastern and central United States and lifelines throughout the country that are found in zones of low, moderate, and high seismicity.

NCEER's research and implementation plan in years six through ten (1991-1996) comprises four interlocked elements, as shown in the figure below. Element I, Basic Research, is carried out to support projects in the Applied Research area. Element II, Applied Research, is the major focus of work for years six through ten. Element III, Demonstration Projects, have been planned to support Applied Research projects, and will be either case studies or regional studies. Element IV, Implementation, will result from activity in the four Applied Research projects, and from Demonstration Projects.



Research tasks in the **Lifeline Project** evaluate seismic performance of lifeline systems, and recommend and implement measures for mitigating the societal risk arising from their failures or disruption caused by earthquakes. Water delivery, crude oil transmission, gas pipelines, electric power and telecommunications systems are being studied. Regardless of the specific systems to be considered, research tasks focus on (1) seismic vulnerability and strengthening; (2) repair and restoration; (3) risk and reliability; (4) disaster planning; and (5) dissemination of research products.

The end products of the **Lifeline Project** will include technical reports, computer codes and manuals, design and retrofit guidelines, and recommended procedures for repair and restoration of seismically damaged systems. The **structures and systems program** constitutes one of the important areas of research in the **Lifelines Project**. Current tasks include the following:

1. Continued testing of lightly reinforced concrete external joints.
2. Continued development of analytical tools, such as system identification, idealization, and computer programs.
3. Perform parametric studies of building response.
4. Retrofit of lightly reinforced concrete frames, flat plates and unreinforced masonry.
5. Enhancement of the IDARC (inelastic damage analysis of reinforced concrete) computer program.
6. Research infilled frames, including the development of an experimental program, development of analytical models and response simulation.
7. Investigate the torsional response of symmetrical buildings.

This report presents a methodology which a utility can use to fold mitigation for seismic hazards into its ongoing repair and replacement program. The methodology was developed specifically for buried pipeline components within the Southern California Gas Company (SoCalGas) system. Both transmission and distribution pipeline systems are considered; however, suggested procedures differ, due in part to the importance and relative lack of redundancy (i.e., interconnectedness) for transmission pipe.

In the past, the SoCalGas repair and replacement program focused on corrosion damage. The new methodology incorporates potential seismic damage as characterized by areas of potential ground failure. As part of this effort, a new procedure for estimating corrosion leakage rates in "data-poor" areas is proposed.

The report describes realistic mitigation procedures for buried pipeline components which is one of the objectives of NCEER's Lifeline Project.

ABSTRACT

This report completes the review of procedures used by the Southern California Gas Company to optimize decisions on pipeline replacement and repair. In addition to discussions with the Engineering Design Department, meetings were also held with representatives from System Planning, Transmission and Distribution. This study was conducted as a joint effort between EQE International and Cornell University. Partial support for this effort was received from the National Center for Earthquake Engineering Research.

This report is comprised of two major parts: (1) a report that discusses a plan for consideration of seismic and corrosion risks under a common program, and (2) a report that summarizes the development of improved corrosion leakage models for the Southern California Gas Company (Appendix B).

The main conclusions of this report are three-fold:

1. It is possible to develop a consistent, company-wide pipe repair/replacement methodology based on minimizing expected costs from corrosion-related failures, and increasing the seismic resistance and safety of the system. For Transmission, this program is based on refining the delineation of areas of potential ground failure (i.e., liquefaction) that are responsible for the majority of the seismic risk. For Distribution, this program is based on using EPOCH (a computer program developed by Distribution to optimize economic decisions on pipe repair/replacement based on corrosion risks) as a major element; additional criteria are applied afterward to decide whether pipes initially identified for repair should be replaced for seismic hazard mitigation purposes.

2. Current methods for predicting pipeline leakage based on corrosion failures appear to be adequate when sufficient repair data are available. Improvements can be made by incorporating the "age dependent" model developed in this study that allows for prediction of leakage rates based on one or two data points. An analysis of repair data found that a key parameter in establishing future corrosion leak rates is the age at which the first leak is discovered. When spurious data were removed from the

data set, it was observed that the rate of increase of leak rates increases with the age at first leak. By incorporating this new parameter, the assessment of future leakage can be expanded to include more pipe, such as an additional 19 percent in the pilot study. It must be cautioned, however, that the analysis performed in this study was for a small area of the total system. Further investigation of other areas would need to be performed in order to verify whether the trends observed in this study are general trends.

3. A number of recommendations are made regarding further steps for this study. The most important recommendation is to extend parts of the Feasibility study so that (1) a procedure for integrating seismic and corrosion risks for distribution pipelines can be tested for a small area of the system, and (2) the details of a more integrated, interdepartmental program can be developed and tested.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

APPENDICES

LIST OF TABLES

LIST OF FIGURES

SECTION 1
INTRODUCTION

As the cost environment within which gas utilities operate becomes more competitive, issues such as pipe repair versus pipe replacement become more important. Decisions to automatically replace generalized categories of pipe without a cost/benefit analysis are rapidly becoming obsolete, primarily because of excessive costs. At the same time, the ability to assess future risks associated with pipeline failure are becoming more keenly developed. The use of well-managed databases has allowed utility companies to examine in detail the probability or likelihood of experiencing certain kinds of pipe failures. This information, combined with an assessment of the impact of these failures, has allowed gas utilities to compare the benefits and risks of adopting alternative strategies for pipe repair and replacement. In general, the actual strategy for repair or replacement will depend on the particular characteristics of the utility and the goals of their replacement program.

In June of 1992, the Southern California Gas Company (SoCalGas) authorized EQE International and Cornell University to perform an independent assessment of current SoCalGas pipe repair and replacement strategies. The primary focus of this program was on risk assessment, and economic and safety issues related to pipe repair/replacement. Because a large part of this effort dealt with an analysis of risks associated with earthquakes, partial funding for this project was provided by the National Center for Earthquake Engineering Research (NCEER).

The intent of this study is to help SoCalGas develop a company-wide strategy for replacement of current and future steel pipelines within its system. To accomplish this, the study has been divided into two phases: feasibility and implementation. This particular report summarizes the feasibility phase in which a general methodology for making decisions regarding steel pipeline integrity has been developed. In addition, a portion of this methodology has been applied to a small area within the SoCalGas system. Whereas the Cornell report emphasizes pipe repair/replacement for transmission and distribution supply lines, the EQE report concentrates on distribution pipelines. In the implementation phase, the general methodology will be refined, tested for additional portions of the system, and implemented with SoCalGas engineers as a continuing program to assess pipeline conditions and set cost-effective priorities for steel pipeline repair and replacement.

The following tasks were performed to meet the objectives of the feasibility phase:

1. Review current programs being used by the Transmission and Distribution Departments of SoCalGas for prioritizing pipe repair and replacement.

2. Recommend improvements in existing methodologies, and suggest ways of integrating these improvements to form a more consistent, systematic approach to planning.

3. Review and refine risk models to reflect more accurately the risks associated with different pipe repair and replacement strategies.

4. Suggest ways of utilizing more detailed information on the location of potential liquefaction areas in estimating future earthquake risks to pipelines.

5. Develop a framework for a comprehensive system integrity and pipe repair/replacement methodology.

In general, these tasks parallel those completed by Cornell University for transmission and distribution supply pipelines.

This report is organized into six major sections, including this introduction. Section 2 discusses the interaction of the project team with SoCalGas personnel. A number of meetings were held between EQE, Professor T.D. O'Rourke of Cornell University and SoCalGas personnel from the Engineering Design, System Planning, Transmission and Distribution Departments to discuss the objectives and status of the various tasks. Section 3 identifies important issues and concerns regarding the development of a system-wide pipe repair/replacement program. Issues such as pipe repair vs. replacement, seismic vs. non-seismic risks, and short-term vs. long-term planning are discussed. Section 4 discusses a general methodology for combining the risks from various hazards or effects. Separate discussions are given for transmission and distribution systems. Section 5 presents the major contribution of the feasibility study, i.e., the development of improved corrosion leakage models. Using data from a portion of the SoCalGas system, an analysis was made of current techniques for predicting future leaks due to corrosion. As a result of this analysis, several recommendations were made with regard to better use of the data and new models for estimating corrosion related leakage. The results of this corrosion study are documented in detail in a separate report that is attached here as an appendix. Finally, Section 6 recommends future steps in this study. One important recommendation is to extend the feasibility study to allow for a more complete integration of risks (i.e., earthquake and corrosion) in establishing pipe repair and replacement priorities. This analysis would be applied to the same pilot area selected for the corrosion analysis.

SECTION 2
INTERACTION WITH SOUTHERN CALIFORNIA GAS COMPANY PERSONNEL

An important part of this project was the interaction between the project team and SoCalGas personnel. This interaction was important in understanding the priorities assigned by each SoCalGas department to each of the project tasks. Additionally, this interaction was used to refine the objectives and scope of critical tasks. The following subsections discuss the meetings that were held throughout the project, information that was received from SoCalGas, and the outcome of this interaction.

2.1 PROJECT MEETINGS

Numerous project meetings were held to solicit input from the various SoCalGas departments. Meetings held early in the project schedule (August 5 and September 10, 1992) to help define the focus of the study included representatives from Distribution, Engineering, Planning and Transmission. Several interim meetings (September 29, and October 12, 1992) emphasized the pilot distribution system corrosion leakage analysis. Later meetings summarized preliminary project results and functioned as project status updates (November 10 and December 23, 1992, and January 19, 1993). Table 2-1 summarizes the general purpose of each meeting, and lists EQE, SoCalGas, and Cornell personnel in attendance.

2.2 INFORMATION SUPPLIED BY SOCALGAS

During the course of the project meetings, various documents and studies prepared by SoCalGas were identified for our review. These documents described current programs and methodologies used by SoCalGas to prioritize pipeline replacement. These include:

- <u>Value Chain Analysis of the Pre-WWII Transmission Pipeline Replacement Program</u>, SoCalGas (Transmission), November, 1991
- <u>Underground Piping System Replacement Assessment</u>, G.E. Strang, SoCalGas (Engineering), May, 1986

Table 2-1

SUMMARY OF PROJECT MANAGERS

DATE	GENERAL PURPOSE	MEETING LOCATION	EQE	CORNELL	SoCalGas*
8/5/92	Project Kick-Off Meeting Orientation to SoCalGas Issues	SoCalGas - LA	Eguchi Honegger	O'Rourke	Ackart (T) Becker-Castle (R) Butler (D) Conley (D) Constantine (E) Gailing (T) Haynes (E) Moore (E) Nose' (E) Saad (T) Sam (E) Stevens (E) Wellman (D)
9/10/92	Follow-up to Kick-Off Meeting - Refinement of Issues/Scope	SoCalGas - LA	Eguchi Honegger Seligson		Conley (D) Hammer (D) Mansdorfer (T) McNorgan (E) Stevens (E) Wellman (E)
9/29/92	Meeting to collect data for pilot study (corrosion leakage)	SoCalGas - Torrance Division	Eguchi Honegger Seligson Shu		Blood (D) Conley (D) Hammer (D) Jordan (D) Moore (E)
10/12/92	Follow-up meeting to refine study area data	SoCalGas - Torrance Division	Seligson Shu		Blood (D) Hammer (E)
11/10/92	Project Team Meeting - Status Report	EQE - Irvine	Eguchi Honegger Seligson Shu	O'Rourke	McNorgan (E) Moore (E)
12/23/92	Presentation of preliminary results for pilot study	SoCalGas - LA	Eguchi Seligson Shu		Becker-Castle (R) Conley (D) Dowell (E) Gailing (E) Haynes (E) Madariage (E) Moore (E)
1/19/93	Discussion for report outline, Confirmation of deliverables	EQE - Irvine	Eguchi Seligson Shu		Dowell (E)

Table 2-1 (Continued)

SUMMARY OF PROJECT MANAGERS

DATE	GENERAL PURPOSE	MEETING LOCATION	EQE	CORNELL	SoCalGas*
7/8/93		SoCalGas - LA	Eguchi Seligson	O'Rourke	Becker-Castle (R) Conley (D) Gailing (E) Haynes (E) McNorgan (E) Stevens (E)

* Note: (D) = Distribution (E) = Engineering (P) = Planning

(R) = Research (T) = Transmission

- "Engineering Report, Special Pipeline Replacement Program, - 1994 Rate Case", SoCalGas (Engineering), June, 1992.

- A sample data sheet and flow chart describing EPOCH (Efficient Pipeline Operation in a Competitive Habitat), the economic repair-replace decision-making program under development by Distribution.

- Annual report for calendar year 1992, Gas Distribution System.

In addition, other reference material identified by Transmission staff was provided:

- J.F. Kiefner and P.H. Vieth (1991), "Methods for Prioritizing Pipeline Maintenance and Rehabilitation", Pipeline Risk Assessment, Rehabilitation and Repair Conference.

- W.E. Martinsen and J.B. Cornwell (1991), "Use and Misuse of Historical Pipeline Failure Data", Pipeline Risk Assessment, Rehabilitation and Repair Conference.

- W.K. Muhlbauer (1991), Dow Chemical Company, "RIPS - a Pipeline Safety Evaluation System", Pipeline Risk Assessment, Rehabilitation and Repair Conference.

- N.A. Townsend and G.B. Fearnehough (1986), British Gas Corporation, "Controlling Risk From U.K. Gas Transmission Pipelines", 7th Symposium on Line Pipe Research, American Gas Association.

2.3 OUTCOME OF INTERACTION

As a result of the discussions with various SoCalGas personnel and review of relevant background material, the project team was able to:

- identify the general framework within which any SoCalGas pipeline replacement program must operate

- understand replacement programs and strategies currently in place at SoCalGas, and evaluate current risk assessment techniques

- identify issues of importance to the various departments (see Section 3.0)

- identify operational differences between distribution and transmission that might impact implementation of a uniform pipe replacement strategy (see Section 3.1)

- understand the linkages between Distribution, Transmission, and System Planning (see Section 3.3)

- identify areas where the project team might make significant contributions to existing procedures (see Section 5.0).

One of the more important outcomes of this interaction was the decision to refocus development efforts from economic modelling to risk assessment. During the initial stages of this project, it was pointed out that a significant internal effort was being undertaken by Distribution to develop a computer program capable of making decisions regarding pipe repair or replacement based on economic considerations. Because of the proprietary nature of that program, few details were provided to the project team on the algorithms used to forecast leaks caused by corrosion or the methods used to calculate costs and benefits. As a result, it was collectively decided that EQE's efforts should focus on an independent development of corrosion leakage models, and that recommendations be provided on how best to utilize the repair data available to SoCalGas engineers.

In order to provide some guidance to SoCalGas on how current methods for pipe repair/replacement can be integrated with methods that focus on seismic risks, a general methodology has been developed. This methodology, discussed in Section 4.0, emphasizes a prioritized replacement program for transmission and distribution supply lines, and an optimization program for pipe repair/replacement for Distribution built around the current Distribution corrosion program EPOCH.

SECTION 3
PERCEIVED ISSUES AND CONCERNS

In the course of this project, several issues relevant to the development of a consistent replacement strategy were identified. It was clear from discussions with SoCalGas personnel, that the issue of pipe repair and replacement was perceived differently by the various departments. The departments that are directly impacted by the issue of pipe repair/replacement include:

- System Planning
- Transmission
- Distribution
- Engineering Design

Addressing the pipe repair/replacement problem from a company-wide basis requires an understanding of the relevant issues for each department. It is possible that issues affecting one department may, in fact, not be considered significant by the other departments. One reason for these differences may be the level of risk associated with pipeline failure. The risk resulting from failures on transmission lines, for example, may be considered more significant than a distribution main failure, thus necessitating a stronger safety component. Another reason for implementing different replacement strategies may relate to the number and frequency of repairs made on each system. Because numerous repairs are made to the distribution system each year, the cost to maintain the system becomes a critical factor. Therefore, strategies to reduce the overall economic cost of maintaining the system become more important.

The following discussions underscore some of the major issues that must be addressed to formulate a company-wide approach to pipe repair/replacement. In general, these issues fall into three categories: pipe repair versus pipe replacement, seismic versus non-seismic risks, and varying time frames for planning.

3.1 REPAIR VS. REPLACEMENT

In order to develop a single pipeline replacement methodology that would be applicable to both transmission and distribution, it is instructive to identify our understanding of operational differences with respect to pipeline replacement that could impact implementation.

3.1.1 Distribution - "Repair vs. Replace"

Routine repair/replacement decisions for Distribution piping are generally reactive - Distribution responds when a leak is reported or found as part of scheduled surveys. Serious leaks (Codes 1 and 2) are repaired immediately, or within two weeks, while less serious leaks (Code 3) that require action within one year, become part of the "Repair vs. Replace" decision-making process. That is, pipeline replacement is only an option for pipeline segments with Code 3 leakage pending. Currently, SoCalGas is in the process of implementing EPOCH, a computer program which quantifies the cost of repair and replacement alternatives for Distribution piping. The results of EPOCH provide the repair/replace decision, as well as a basis for prioritization of projects.

In response to CPUC suggestions, a limited number of distribution pipeline classes have been identified for inclusion in a special pipeline replacement program.

> Attention by the CPUC Staff to "reportable incidents" involving main or service failures has increased since 1980. The Staff has suggested planned removal of "families" of gas facilities unless the company demonstrates that the "reportable" incident involved unusual conditions unlikely to be repeated in the future (Strang, 1986).

Classes slated for replacement include certain plastic services, copper mains and services, cast iron mains, bare steel main in conduit, and Pre-World War II supply lines in urban areas. Replacement priorities have been set according to safety concerns, continuity of service, and certain economic factors, such as "... prevention of cost from incidents, judgements and assessments" (Strang, 1986)

3.1.2 Transmission - Prioritized Replacement

For high pressure transmission lines, any failure is a significant incident, and not a simple leak. Failures are promptly repaired, and replacement is not a viable option in response to this type of failure. In other words, there is no "routine" pipeline replacement program for transmission pipelines. Replacements are performed on a systematic basis; certain vulnerable or mechanically deficient classes of pipe, or pipe in areas of perceived seismic hazard have been identified and are scheduled for long-term replacement. These replacement programs have been authorized by the CPUC. With regard to pre-World War II pipe, the Value Chain Analysis report stated,

> As of the early 1980's... it was recognized that the condition of some of this pipe had deteriorated. Also, several reports by consultants indicated that the poor weld quality in pipelines built prior to WWII made them significantly more susceptible to failures during earthquakes. As a result, the Company sought and received authorization from the CPUC for capital expenditures over and above traditional levels to fund a special replacement program.

Priorities are set based on relative risk and the level of approved funding. Transmission's approach is, therefore, generally pro-active - replacements are made in anticipation of possible high cost, high impact failures. Other replacements are made in response to planning issues, such as anticipated or actual changing demands.

3.2 SEISMIC VS. NON-SEISMIC RISKS

Because of the difference in the nature of transmission and distribution systems, different risks will dominate, and failures will have different impacts. Pipeline failures are generally attributed to one of several causes: corrosion, third party damage, material failure, construction defects, or seismic loads. These causes may be grouped into predictable and non-predictable failures. Corrosion effects are generally predictable, while third party damage, construction defects and material failure are not. The unpredictable failure modes, are, for the most part, controllable. The damage caused by seismic loads is certainly quantifiable, but the probability of occurrence must be taken into consideration as well.

3.2.1 Distribution

Gas distribution systems are usually extensive, highly netted, highly redundant networks of mostly small diameter, medium pressure pipe. SoCalGas distribution mains are primarily steel (64.8% as of the end of 1992, according to the annual report for calendar year 1992), with the remainder comprised of plastic (35.1%), and cast iron (0.01%). Distribution supply lines, which essentially function as transmission lines, are treated in this discussion as transmission lines. Because most repairs can be made to low pressure lines while under pressure, leakage or failure of an individual pipe will have little impact on supply to the surrounding area.

The majority of repairs required by the distribution system are caused by corrosion. For example, a detailed study of a small area within the City of Torrance revealed that 70% of the repairs made between 1970 and 1991 were attributed to corrosion. It is reported that

> Company-initiated leakage surveys, routine inspection procedures and pipe replacements in advance of public improvements largely identify and control hazardous conditions which develop slowly over time. Serious leaks, which generate immediate hazards, are primarily related to: 1) materials defects which take years to cause failure; 2) accidental damage by outside forces; or 3) significant events initiated by earthquakes (Strang, 1986).

The majority of risks for Distribution i.e., corrosion risks, are being addressed through the routine pipe repair/replacement program. The remaining risks (material deficiencies and earthquake vulnerability) are currently being included qualitatively under the Special Pipeline Replacement Program.

3.2.2 Transmission

Gas transmission systems are generally non-netted, high pressure systems with limited redundancy. SoCalGas transmission pipelines are exclusively made of steel, and are typically large in diameter. The impact of failure of transmission pipelines, as well as distribution supply lines, may not be insignificant. The transmission system transports gas from out of state, to and from storage fields, and from local producers.

> The distribution supply system, operating at higher pressures and larger diameters <than the remainder of the distribution system>, is operationally critical to continued supply during peak demands or emergency conditions. In many cases, these supply lines constitute single sources of supply to large areas, many

within the central city, i.e. Hollywood, Beverly Hills (Strang, 1986).

Corrosion leakage is not expected to be a problem for SoCalGas transmission lines, because of the high priority placed on cathodic protection and monitoring. Between the years of 1983 and 1990, the transmission system averaged only 24 leaks per year, or 0.007 leaks per mile (or 0.004 leaks per km) of pipe per year (SoCalGas, 1991). This can be contrasted to figures for steel without cathodic protection in the distribution system. For the 12 year period between 1973 and 1984, bare steel in the distribution system averaged 1.18 repairs per mile (or 0.73 repairs per km) per year, and coated steel averaged 0.45 repairs per mile (or 0.28 repairs per km) per year (estimated from data provided in Strang, 1986). The transmission system suffers corrosion leakage up to 170 times slower than the unprotected steel in the distribution system.

According to a study by U.K. Gas, rupture of high pressure transmission lines caused by corrosion is unlikely at stress levels below 58% of SMYS (SoCalGas, 1991), and most of the older SoCalGas lines are operated well below this threshold.

The more significant risk to the transmission system are the non-predictable failures - "sudden failure due to unusual loading conditions, usually earthquakes, related to poor construction techniques or materials" (SoCalGas, 1991) Certain pipe classes have been identified as having vulnerable welds. These pipes have failed in the past under unusual loads. Unusual loading conditions include (SoCalGas, 1991):

- pipeline exposure in cold temperatures causing contraction and weld failure,
- use of construction equipment over pipelines cracking welds,
- train derailment, and
- earthquake loads.

The risk and impact of failure due to earthquake loads has been addressed qualitatively by Transmission in the Value Chain Analysis (SoCalGas, 1991). Vulnerable classes of pipe have been identified for replacement based on location through identified seismic hazard zones in areas of population concentration, where the impact of failure would be most significant. Priorities are based on safety, cost, and reliability of delivery.

3.3 PLANNING TIME FRAMES

Because Distribution and Transmission are governed by different risks and replacement procedures, the time frame for replacement planning varies significantly.

Distribution is primarily concerned with the predictable effects of corrosion, and time limitations with respect to public works moratoriums. As a result, the time frame within which Distribution currently operates is five years, as reflected in EPOCH. Links to the System Planning Department are limited - projects require System Planning review only if the cost exceeds $200,000 or if the project crosses divisional boundaries. It is presumed that Distribution consults the "Master Plan" in designing replacement projects.

On the other hand, because transmission replacement projects involve large capital outlays, it is more closely tied to System Planning. Replacements proceed in anticipation of infrequent earthquake events, in response to anticipated changing loads, and in response to construction projects impacting the pipeline right-of-way. The planning time frame is by necessity, significantly longer than that of Distribution.

SECTION 4
GENERAL METHODOLOGY FOR PIPELINE REPLACEMENT DECISIONS

In this section, a general methodology is outlined for making optimal decisions regarding pipeline replacement. Whereas other parts of this study have focused on individual methods of quantifying seismic or corrosion-related risks, this section begins to define how these risks can be balanced in an overall risk reduction program.

The methodology for optimizing pipeline replacement decisions can be described by seven basic steps, as diagrammed in Figure 4-1. The basic steps apply to both Transmission and Distribution, but the implementation will vary depending upon each department's operation. In each of the first four steps, a weighting factor (based on guidelines to be developed by EQE, Cornell University and SoCalGas) is used to facilitate project prioritization. These factors, designated as P (Pipe factor), D (Demand factor), S (Seismic hazard factor), and O (Other, non-seismic factor) are described in the following sections.

4.1 PIPELINE REPLACEMENT METHODOLOGY FOR TRANSMISSION

Various transmission pipelines have been identified for replacement through a systematic review of pipeline class and location. Other factors may be incorporated into the assessment in a consistent manner.

4.1.1 Review Pipeline Data

This task entails a review of pipeline data for the segment under consideration. Pipeline material (i.e., weld-type), age, diameter, pressure, and cathodic protection are all key factors. Additional emphasis would be placed on operational history. A review of each individual pipeline's operational history might allow for consideration of poor performers in otherwise acceptable pipe classes.

This step also includes determining whether the pipe segment is considered vulnerable or mechanically deficient, or falls into a class of pipe included in previously established long-term replacement programs. All of the information gathered is used to estimate the pipeline data weighting factor (the "P" factor).

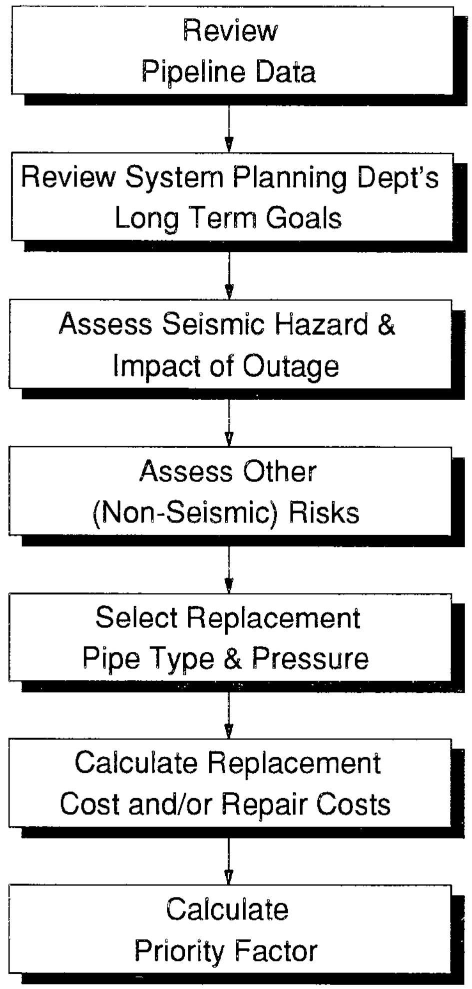


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Figure 4-1: General Methodology for Pipeline Replacement Decisions

4.1.2 Review System Planning Department's Long-Term Goals

This phase of the methodology entails checking with System Planning to determine whether the segment under consideration is within or serves an area of changing demand, and is scheduled for upsizing, downsizing, or abandonment. Currently, this data is contained in a hard-copy "Master Plan". This information is used to select replacement pressures or diameters, as well as to compute a "Demand" weighting factor ("D" Factor).

This process could be streamlined with the implementation of Geographic Information System (GIS) methods. A digital map could be developed by System Planning identifying areas of "Planning Concern". Such a map would be "dynamic" and reflect on-going system alterations, identify areas of expected growth or development, and include information on expected loads and service requirements. This map could be made available to Transmission such that a quick on-screen review would indicate future requirements for any pipe in question. Alternatively, if the pipe falls within an area of "Planning Concern", it could be a "flag" requiring a project review by the System Planning Department.

Transmission line replacement is more closely tied to the goals of Planning than Distribution line replacement. Transmission, by nature, must more directly address changing regional demands. System Planning Department input during review of existing lines helps identify the optimal size, pressure and location for a given pipeline. Possible links to distribution projects should also be taken into consideration. This may be accomplished through examination of hard copy plans, on-screen maps or direct System Planning Department input.

4.1.3 Assess Seismic Hazard and Impact of Outage

The main stimulus for transmission line replacement is anticipation of sudden failure due to seismic hazards. Detailed delineation of these hazards is essential for development of a multi-risk decision-making procedure. The implementation of this step presupposes the existence of seismic hazard maps at a scale appropriate for application to the transmission system. Some mapping has been performed in previous studies by consultants, but additional maps would be required. Justification of such expenditures might come in the form of savings gained by reducing the size of hazard areas as currently identified, and the corresponding reduction in the amount of pipe to be replaced. Because a consistent company-wide approach is preferable, the most likely proponent of systematic hazard mapping would be the System Planning Department. While the areal extent of useful maps varies significantly between Transmission and Distribution, a program to identify hazard areas significant to both systems would, in the long run, save money as well as improve safety and system reliability.

Possible candidate hazards for mapping include surface fault rupture, liquefaction susceptibility, landslide, lateral spread, and strong ground shaking. Information is currently available on the topics of landslide, liquefaction and surface fault rupture. Consideration of these seismic hazards, if available in digital form, would be straightforward to implement. For example, the California Division of Mines and Geology (CDMG) has an on-going program to map active and potentially-active fault traces within the state at a scale of 1 inch = 2,000 feet. These maps are developed and published under the auspices of the Alquist-Priolo Special Studies Zone Act of 1972, and are readily available. Such maps could be consulted in hard-copy map form, or be digitized for automatic on-line overlay. Strong ground shaking maps, if required, could be developed in either probabilistic or scenario-based forms.

For this step in the methodology, available seismic hazard maps are consulted to determine if the pipe segment under study crosses any of the various hazard zones. In conjunction with relative pipeline vulnerability data, this information is used to identify optimal repair/replacement techniques, and replacement material. Alternatively, the presence of the seismic hazard may activate the requirement for a review by System Planning.

The impact of pipeline outage is also considered. If the pipeline in question is a critical transmission or supply line, whose outage would isolate numerous customers, consideration is given to possible relocation, additional redundancy, or placement of isolation valves to limit outage and speed restoration. Such an assessment requires information on service areas, supply, and redundancy. The seismic hazard information and impact assessment are utilized to develop the seismic hazard or "S" weighting factor.

4.1.4 Assess Other Non-Seismic Risks

Additional risks threatening transmission pipelines may be addressed in this step of the methodology. Although the VCA report dismissed the other identified "unusual load" risks for the system as a whole, there may be certain pipeline segments wherein these risks should be considered. Other, as yet unidentified risks, could be easily added into the assessment as well. Any such conditions would be incorporated here into the "Other" risk or "O" Factor.

4.1.5 Select Replacement Strategy

Based on the planning goals, seismic hazard and other risk exposure, an optimal replacement strategy for the transmission line under review is developed. Possible strategies include:

- Do not replace at this time
- Do not replace, but perhaps increase monitoring to track some operational deficiency
- Replace with a specified material, diameter and pressure to address planning concerns within a certain time frame
- Relocate pipeline to avoid seismic hazard (that is, install an alternate line and abandon the more hazardous route)
- Develop an alternate "creative" replacement solution including cooperative planning efforts with Distribution. If the pipeline was subject to a System Planning review, an alternate replacement solution may have been suggested. For example, a System Planning review may indicate that an upgrade of a distribution line would allow for the abandonment of the transmission line scheduled for replacement. A cooperative replacement program would allow for cost savings and system optimization.

4.1.6 Calculate Replacement Costs

This task includes all the cost calculations. Based on local cost data, as well as information on future public works projects, the cost of the replacement strategy as specified by the preceding needs and risk assessments is calculated. The results of this step allow for replacement prioritization that incorporates long-term planning goals, as well as risk reduction measures.

4.1.7 Calculate Priority Factor

The four weighting factors estimated in tasks 1 - 4 are combined to develop one overall weighting factor associated with the replacement strategy. This priority factor allows for the relative ranking of various replacement projects based on the needs and risk assessment. The development of criteria for the Transmission priority factor is a critical element in the application of this methodology. Because of the large expense associated with transmission line replacements, and limited capital budgets, the priority factor will essentially determine the sequence of pipeline replacements. For this reason, substantial attention should be given to the development of guidelines for priority factor calculation, with input and general approval from System Planning and Engineering Design, as well as Transmission and Distribution. While the guidelines are expected to vary between the two operational units, the general approach should be consistent.

4.2 PIPELINE REPLACEMENT METHODOLOGY FOR DISTRIBUTION

The methodology for pipeline replacement for distribution lines is presented in Figure 4-2. The methodology is built around the use of EPOCH, a computer program developed by Distribution to optimize decisions with respect to repair/replacement of pipelines affected by corrosion. Additional elements proposed in this study are steps to insure that opportunities to improve seismic safety through replacement are not lost. These steps are discussed in the following subsections.

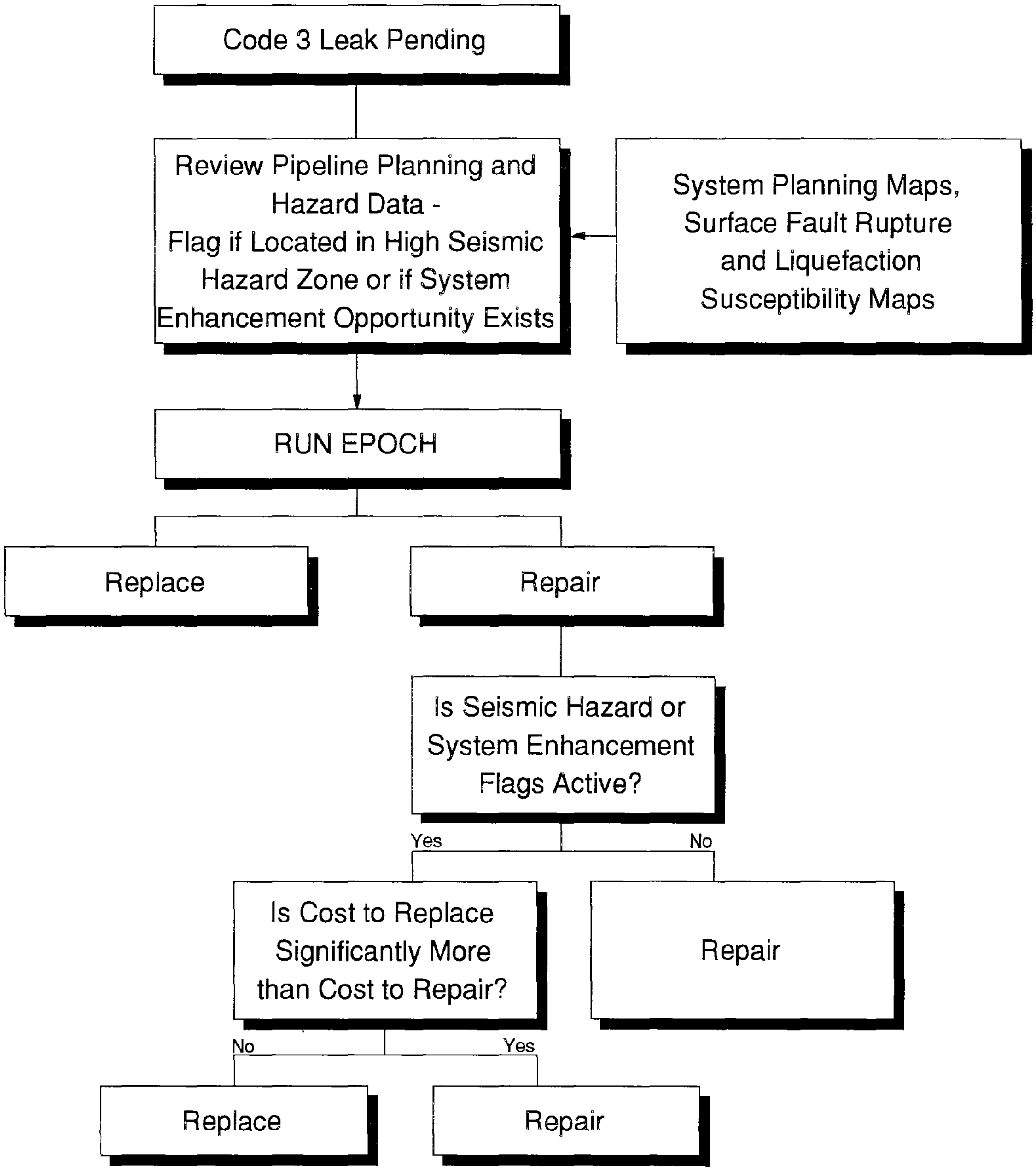

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Figure 4-2: Procedure for Incorporating Seismic Hazard or System Enhancement Data inot Pipeline Repair/Replacement Decisions for Distribution

4.2.1 Review Planning Data

In this step, two types of planning data are reviewed. First, data identifying future changes to the system are reviewed. When changes are anticipated or planned, this information may be used by Distribution to help decide when and how replacement of a particular pipe segment should be accomplished.

In the case of seismic hazards, maps could be available for planning purposes to identify opportunities to improve the seismic safety of the system. Based on criteria that would be established by Engineering and Distribution, any significant benefit, with respect to seismic safety, resulting from replacement would be noted.

One possible basis for this criteria could be the degree of seismic hazard and the seismic vulnerability of the pipe segment. Certain combinations of these two parameters would lead to significant seismic safety benefits through replacement. The results of this review, combined with the results from EPOCH, could lead to replacement decisions that incorporate not only economic considerations but safety considerations as well.

4.2.2 Run EPOCH

In this step, the computer program EPOCH would be run to identify the economic benefits of repair versus replacement. This analysis would be run with the updated models for corrosion leakage. Based on the results of this analysis, pipelines would be classified into one of three categories according to economic considerations:

1. Pipelines that should be replaced.
2. Pipelines that should be repaired.
3. Pipelines that are marginal, i.e., the cost difference between the two options is considered small, and the pipeline could either be replaced or repaired.

In general, the assignment to each of these categories will be based on the expected costs associated with mitigating the effects of corrosion. Categories 1 and 2 should reflect firm decisions based primarily on minimizing future costs. Category 3 can result in 1 or 2, with the addition of information on future growth plans or seismic hazard levels.

4.2.3 Post-EPOCH Analysis

If the results of EPOCH suggest that the best mitigation option is to replace the pipe, then replacement incorporates prudent decisions regarding seismic design or future growth.

If the results of EPOCH indicate that repair rather than replacement is, by far, the best option or strategy, then seismic design and other considerations should be postponed until that pipe segment is re-evaluated.

If, however, the results of EPOCH fall into category 3, that is, a borderline decision to repair or replace, then the results of the seismic and planning review could be used to encourage replacement, if significant benefits would result. If however, no benefits are identified, repair is warranted. By incorporating this added step, Distribution will realize the following benefits:

1. Maintain EPOCH as the primary decision tool for deciding the repair or replacement issue.

2. In marginal cases, decisions can be made to improve the safety and reliability of the system.

3. The integration of this added step would insure that Distribution maintains a proactive program to balance all risks in their evaluations.

In order to test this strategy as an effective method for considering all risks, it is recommended that this procedure be tested in a small portion of the SoCalGas service area. In testing this procedure, the results from both the current seismic study and the corrosion analysis would be used. One possible area for this evaluation would be the Torrance area on which both the Cornell and EQE studies have focused.

SECTION 5
REFINED PREDICTIVE MODELS FOR CORROSION LEAKAGE

During the course of this study, a topic identified by Distribution as requiring further investigation was the development of a more comprehensive corrosion leakage model. Although current methods for predicting corrosion leakage appear to be effective when sufficient repair data are available, there are numerous cases where sufficient data do not exist. For these cases, alternative methods were sought.

To evaluate the current procedure utilized by Distribution to project future leakage due to corrosion, a detailed analysis was performed on a small portion of the Distribution system. The purpose of this pilot study was to determine if an alternate model to predict leakage could be developed from available information. This section presents a brief summary of the pilot study results - the full text of the report is contained in Appendix B.

5.1 PILOT STUDY DATA

The pilot area chosen was a small area within the City of Torrance. This area was selected because it is representative of somewhat older areas experiencing problems related to corrosion. Pipeline maps, including atlas sheets, leak history and leak detection survey maps were collected for the 5 atlas sheet study area. In addition, Distribution supplied a detailed data file, extracted from their Leak Repair Order (LRO) database, that contained repair information recorded for the period 1970-1992.

The majority of recorded main leaks were associated with individual homogeneous (with respect to age, material, diameter, cathodic protection) pipeline segments. A comparison of the leak history maps to the LRO data led to the conclusion that the history maps may provide an incomplete picture of actual segment leakage over time. Only 66% of noted main repairs from the LRO data were shown on the plotted history maps.

5.2 ASSESSMENT OF LINEAR REGRESSION PREDICTION TECHNIQUE

The linear regression technique currently used by Distribution to predict future pipeline leakage was tested (See Appendix A for an explanation of the Linear Regression or Least Squares Statistical Method). Cumulative leak rates (cumulative leaks per 1000 feet of pipe) for individual pipeline segments were plotted versus pipeline age. (Equivalent leaks per kilometer can be computed by multiplying leak rates in thousands of feet by 3.28). A "best-fit" line was developed and plotted, to predict subsequent leakage. Figure 5-1 provides sample results for pipe installed in 1912. As can be seen in the figure, linear regression techniques yield good predictions when sufficient data exists. For the test cases, half of the predictions were within 10% of actual, while 70% were within 27%. The major weakness of this approach is that future performance predictions cannot be made reliably when data are limited (i.e., one historic leak occurrence).

5.3 ALTERNATIVE LEAK PREDICTION METHODOLOGY - THE AGE DEPENDENT MODEL

To enhance prediction in those cases where limited historical leakage exists, an alternate "age dependent" predictive model was developed, based on the pipeline's age at instance of first leak[1]. It was noted from an analysis of the Torrance data, that the rate at which leak rates increase tended to increase with age at first leak. That is, leak rates increased more quickly on older pipe segments than on newer ones. A regression model relating slope of the leak rate to age at first leak in log-linear space was developed for several sample classes of pipe. Figure 5-2 presents a sample model, for steel pipe installed in 1912.

It must be noted here that pipeline segments with high leak rates at younger ages that were subsequently replaced were removed from this data set. This action is explained by noting that the models being developed would be used on pipe with normal corrosion performance, i.e., not exhibiting excessive repairs in short performance periods. In essence, this led to the elimination of all pipe repair data

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1 Note that this leak is the first recorded leak listed in the Leak Repair Order (LRO) database, which begins after 1970. Leaks that may have been repaired prior to 1970 are not included in the present analysis.

associated with pipes that had been replaced between 1970 - 1992. Appendix A discusses more fully the rationale behind this action.

The age dependent model was tested for the same pipeline segments used in the assessment of linear regression techniques. This comparison is graphically

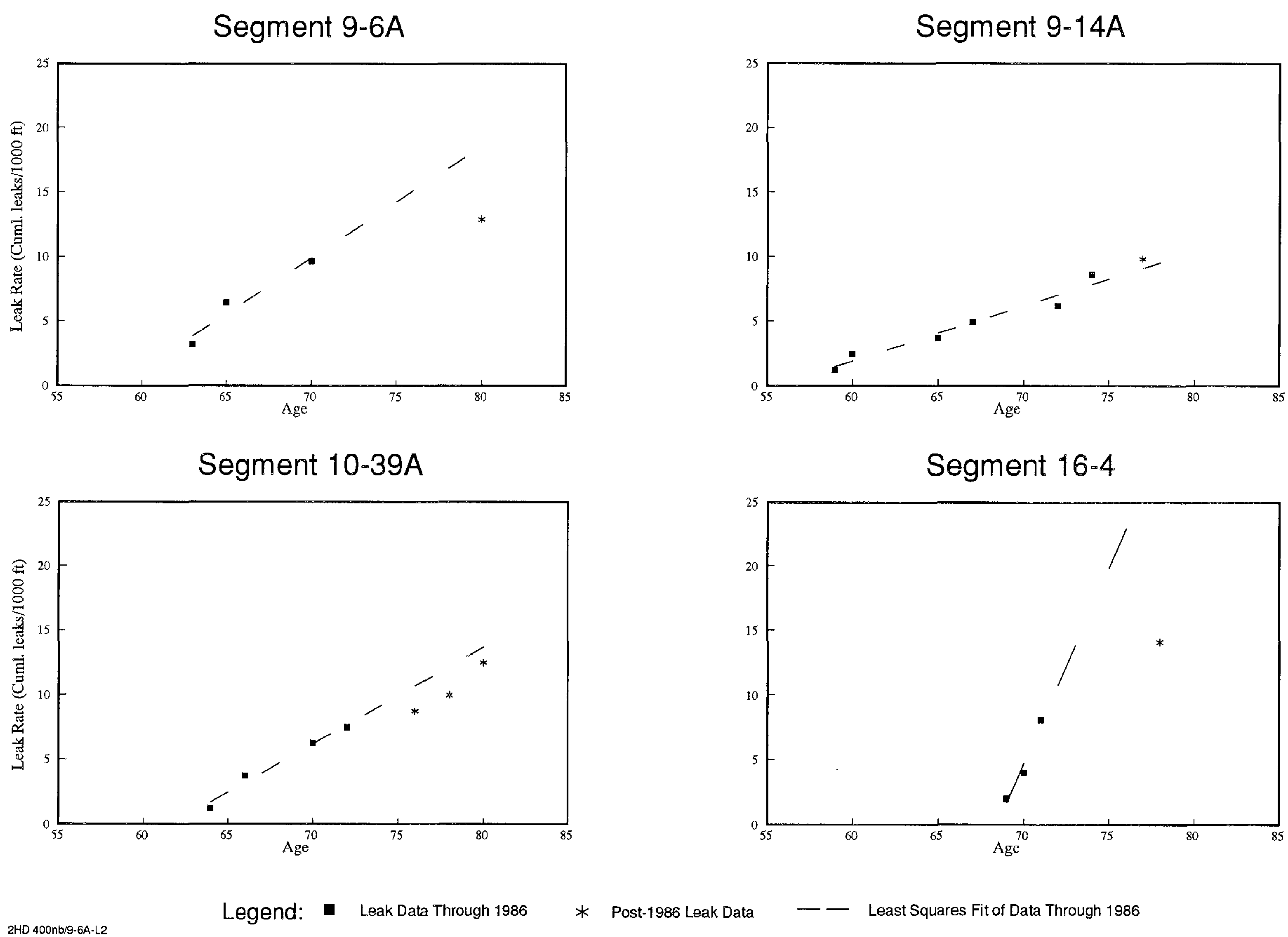

Figure 5-1: Comparison of Leak Rate Prediction from Linear Regression of Data through 1986 to Actual Post-1986 Performance (Pipe Installed in 1912)

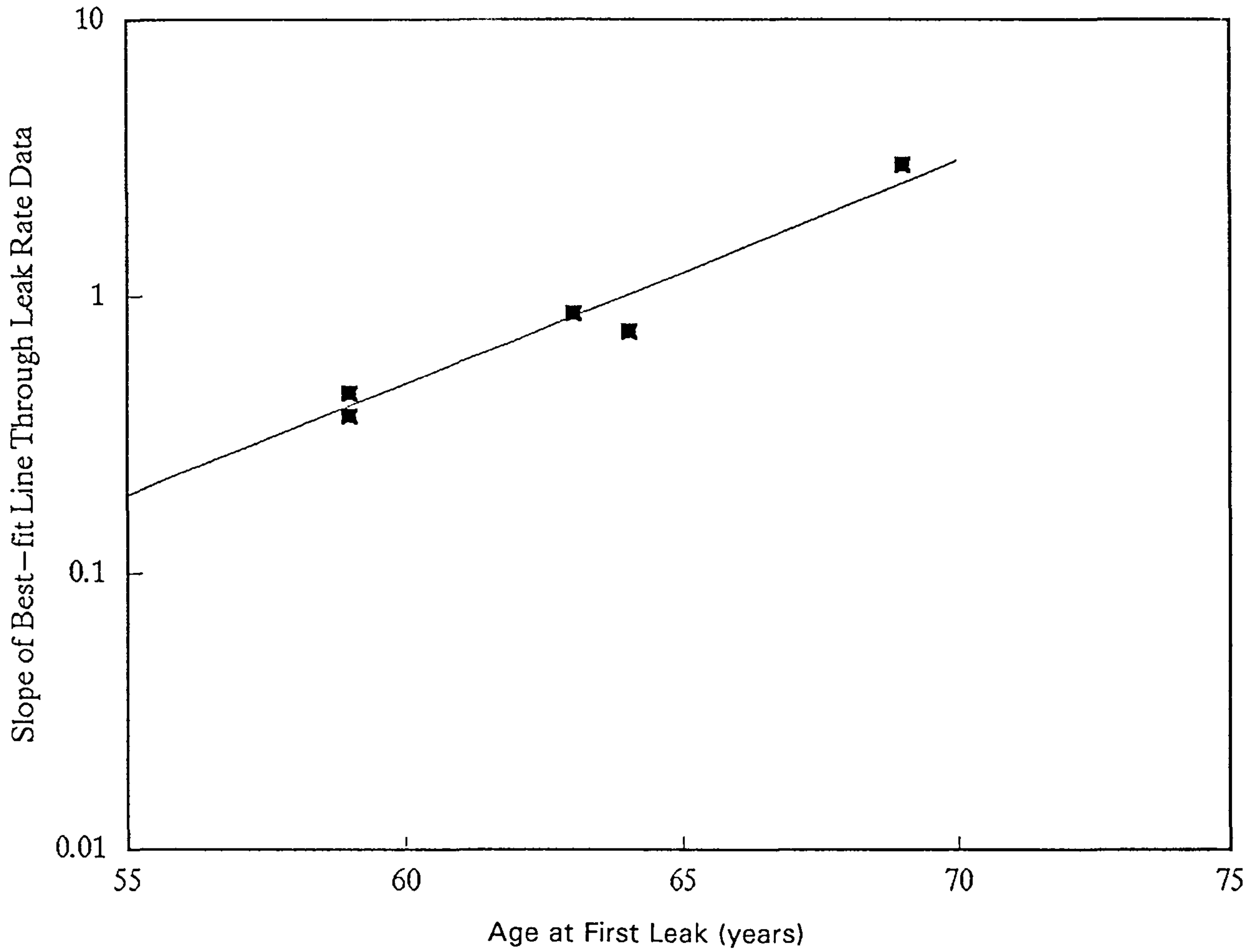

Figure 5-2: Age Dependent Leak Rate Model for Steel Pipe Installed in 1912

displayed in Figure 5-3. This alternative model was shown to be as good as the linear regression model for segments with extensive leakage histories. The model was also evaluated for pipeline segments with minimal leakage histories, as shown in Figure 5-4. This evaluation showed that the model is able to predict leakage within 15% of actual performance in the majority of cases (2/3) for segments with limited historical leakage.

5.4 CONCLUSIONS AND RECOMMENDATIONS FROM THE PILOT STUDY

Several conclusions and recommendations resulted from the pilot study assessment of leakage prediction techniques. These are repeated here:

Conclusions from the Torrance pilot study:

1) The current method of leakage prediction is effective when sufficient leak data exists (i.e., at least three years with leakage)

2) Utilizing the leak history maps to represent historical leakage may underestimate leakage because the map updating procedure which entails physical patching often obscures data, and reporting practices may have varied over time. Other sources of data are available, including the Leak Repair Order database, which includes every pipeline repair made since 1970.

3) An alternative method (the age dependent model) for verifying linear regression predictions and/or estimating pipeline leakage based on limited leakage data can be developed.

In addition to the above conclusions, the following recommendations are made:

1) Since the pilot area used in this study was relatively small, a second analysis is recommended to confirm the trends developed in this first phase. This recommendation should only be implemented if the ability to estimate future leak rates based on limited data is important from the standpoint of the EPOCH program.

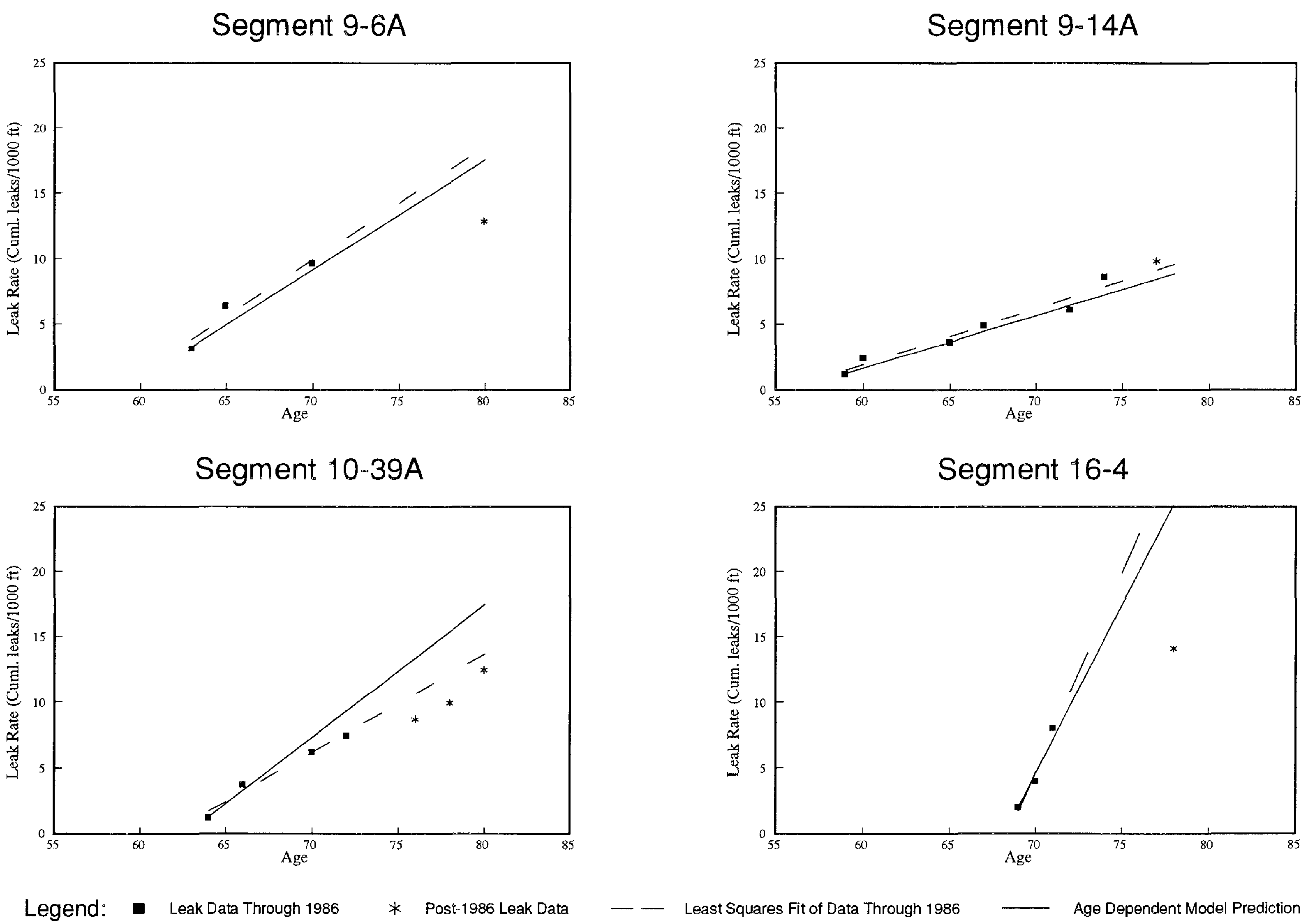

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Figure 5-3: Comparison of Leak Rates Predicted from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1912)

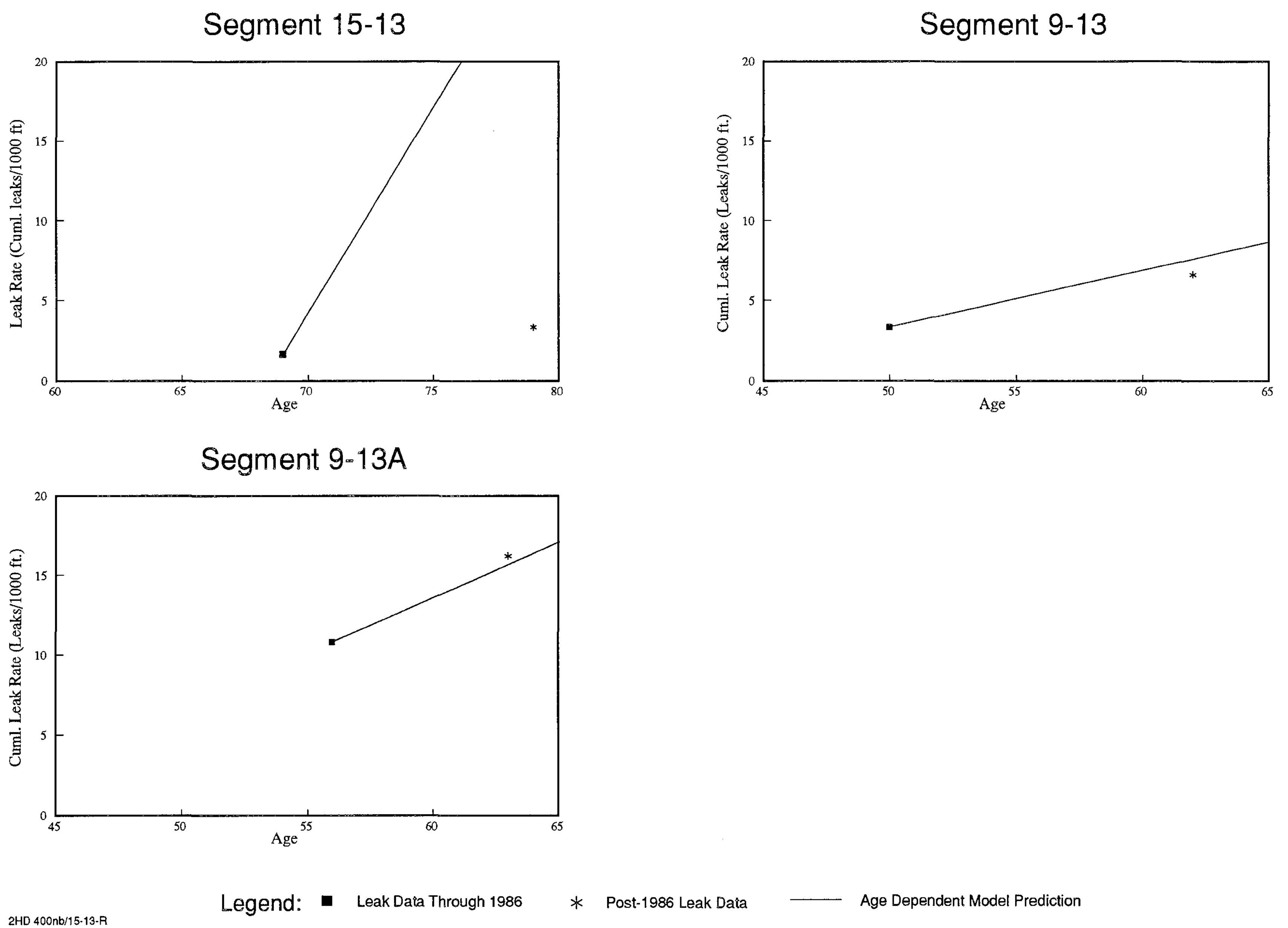


Figure 5-4: Comparison of Predicted Leak Rates from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1927 with Limited Leakage)

2) If further study is justified in this area, two areas are suggested for further study. The first area should be similar, although larger in size, to the Torrance area analyzed in the first phase. The purpose of this assessment will be to confirm the trends observed in the pilot study. In general, the models developed would have the most applicability to these older areas. A second, newer area should be selected to determine if similar models can be developed for other parts of the service area.

3) The same type of analysis could be applied to other pipe classes. Although most corrosion problems appear to affect pre-1936 bare pipe without cathodic protection, there are a limited number of other pipe classes that are also affected by corrosion. One such candidate pipe class is poorly coated steel pipe, without cathodic protection, installed between 1941 and 1957.

SECTION 6
RECOMMENDED REFINEMENTS FOR IMPROVED DECISION-MAKING CAPABILITIES

In this section, recommended refinements to improve SoCalGas's company-wide replacement decision-making capability are presented. Three areas are highlighted: Mapping and Records, Interaction with System Planning, and Incorporation of Seismic Risks.

6.1 MAPPING AND RECORDS

During the course of this study, possible improvements for future record keeping practices as well as several schemes to take advantage of the proposed GIS system were identified.

It was noted as a result of the Distribution pilot study that the utilization of leak history maps as the basis of future leakage predictions may be misleading due to possible incomplete recordation of leaks. Improvements in the record keeping process may be as simple as developing official guidelines for leak recordation, including a simple box to check on the leak repair order form. When this data is entered into the LRO database, it will then be possible to tell if the leak has been noted on the map, and a reminder generated if it has not.

With the implementation of a SoCalGas GIS, certain features could be incorporated into the GIS design to enhance operations of Distribution, Transmission and System Planning. For Distribution record-keeping purposes, the leak history map could be digitized, and be available for on-screen leak notation. The dynamic quality of the map would reflect daily activities, and be available to more than one user at a time. In addition, a database consisting of all information currently in the LRO database could be linked to the map file, allowing for inspection of detailed leak information simply by selecting the noted leak location. Eventually, such information could be tied to EPOCH to allow for retrieval of leakage information on specific pipeline segments automatically.

The GIS would also be an efficient platform to allow timely review of System Planning information during the replacement evaluation process. The development of digital seismic hazard maps, and various planning maps such as "Master Plan" maps, load maps, or areas of "Planning Concern" would speed up the review process. These planning maps would be "dynamic", available on-line, and able to reflect on-going system alterations.

6.2 INTERACTION WITH SYSTEM PLANNING

A significant opportunity exists to link the efforts of Transmission and System Planning, and Distribution and System Planning. For the tasks of recording proposed changes to the system, or maintaining detailed data on seismic hazards, it seems appropriate for the System Planning Department to play a key role. Presumably, detailed data on proposed changes to the system are already being maintained by System Planning. This information, if available in a convenient format for all users, could be accessed by the other departments. This would insure that system information is used consistently by all departments.

With respect to seismic hazard conditions, if detailed maps are developed and maintained by Planning, decisions regarding opportunities for improving seismic safety can be made in a consistent manner by all departments. At this point, the following maps been further investigated:

- Potential Surface Fault Rupture Maps (Alquist-Priolo Fault Maps)
- Liquefaction Susceptibility or Potential Maps (Refinements made by Professor T. O'Rourke of Cornell University)
- Maps identifying areas of significant strong ground motion amplification (e.g., areas overlying soft soils, or deep alluvial deposits)

6.3 INCORPORATION OF SEISMIC RISKS

An area deserving special attention is the incorporation of seismic risks into Distribution planning efforts. As outlined in Section 4.2., a methodology for incorporating seismic risks into the current pipe/replacement format is recommended. Performing this task would help to insure that not only are economic considerations addressed in pipe replacement, but safety and reliability as well.

It was further recommended that this procedure be tested in the Torrance area where extensive work has already been performed by the Project Team on seismic and corrosion problems.

SECTION 7
REFERENCES

O'Rourke, T.D. and M. C. Palmer (1994), "Feasibility Study of Replacement Procedures and Earthquake Performance Related to Gas Transmission Pipelines," NCEER Report No. 94-0012.

Southern California Gas Company (1991), "Value Chain Analysis of the Pre-WWII Transmission Pipeline Replacement Program."

Southern California Gas Company (1992), "Annual Report for Calendar Year 1992; Gas Distribution System."

Strang, G.E. (1986), "Underground Piping System Replacement," Southern California Gas Company Engineering Report.

APPENDIX A
EXPLANATION OF LEAST SQUARES METHOD

If a number of data point pairs (x,y) exist and are assumed to be linearly related, the "best-fit" line through these points can be determined using a "least squares" approach. According to the principle of least squares, "... a line provides a good fit to the data if the vertical distances (deviations) from the observed points are small. The measure of goodness of fit is the sum of the squares of these deviations. The best-fit line is then the one having the smallest possible sum of squared deviations" (Devore, 1982). In other words, a "least-squares" fit or a simple linear regression analysis is the process of defining the constants m and b to fill the equation of the line, $y = mx + b$, such that the variance between the actual (observed) value of y, and the value predicted by the equation is minimized.

In practice, for a given data set $\{(x_1, y_1)...(x_n, y_n)\}$, the constants defining the equation of the best-fit line may be determined as follows:

$$m = \frac{n\,\Sigma(x_i y_i) - (\Sigma x_i)(\Sigma y_i)}{n\Sigma x_i^2 - (\Sigma x_i)^2}, \quad \text{and}$$

$$b = \frac{\Sigma y_i - m\,\Sigma x_i}{n}$$

where;

n = number of (x,y) pairs

REF:

Devore, Jay L. (1982), Probability and Statistics for Engineering and the Sciences, Brooks/Cole Publishing Company, Belmont, California

APPENDIX B

RESULTS OF DISTRIBUTION STUDY:

"AN ASSESSMENT OF CORROSION LEAKAGE MODELS-APPLICATION TO SOUTHERN CALIFORNIA GAS COMPANY DISTRIBUTION PIPELINES"

In June of 1992, the Southern California Gas Company (SoCalGas) entered into an agreement with EQE International and Cornell University to perform an independent assessment of current SoCalGas pipe repair and replacement strategies. The overall program focused on risk assessment, economic and safety issues. The purpose of this particular report is to summarize the project team's investigation of current SoCalGas leak prediction methods for distribution piping, and to suggest ways of improving these methods. Other topics related to earthquake risk and safety, and cost-benefit methods for determining pipe replacement are discussed in other project reports.

The estimation of future pipeline leaks is a concern shared by many owners and operators of natural gas distribution systems. The decision to replace or repair a damaged line often depends upon how the cost to replace compares to the anticipated costs of future repairs without replacement. Generally, the models that are used to estimate future leak rates are based on past pipeline repair data. Statistical models are developed that correlate expected leak rates with pipe material types, pipe age and corrosion protection. As with most models of this type, predictions are generally reliable as long as ample data is available.

Some of the factors that contribute to poor pipeline performance or damage are high soil corrosivities, high pipe-to-soil potentials, mechanical deficiencies, such as improperly screwed joints, and accidents caused by third party damage. In most cases, however, the only failures that can reasonably be predicted are corrosion-related failures.

Modern procedures for corrosion control are generally quite effective. Physical application of pipe coatings to steel pipe extends the life of the pipe many years. Cathodic protection applied to bare and coated steel pipes can also mitigate the effect of corrosion. In addition, many operating companies are installing pipe whose materials are not susceptible to corrosion, i.e., plastic. In summary, corrosion failures appear to be limited to older pipes that were installed without corrosion protection.

The Southern California Gas Company distribution system currently serves 4.65 million customers (P&GJ, 1992) throughout the southern California area. The company has been in existence since the early 1920s. In these early periods, it was common for bare steel pipe without cathodic protection to be installed.

In order to address the corrosion problem, Distribution initiated an aggressive program of cathodic protection and pipe repair and replacement. To determine whether particular pipe segments ought to be replaced or repaired, SoCalGas has developed an in-house computer program, Efficient Pipeline Operation in a Competitive Habitat (EPOCH), that forecasts future leaks and repair costs. The methodology considers three options using a five-year time frame; pipe replacement, repair and installation of cathodic protection, and repair without cathodic protection. An economic analysis compares the estimated costs associated with each of these options.

One of the areas that has concerned SoCalGas personnel is (1) whether the company is maximizing the use of all available pipe repair data, and (2) whether the statistical models that were being developed for use in the EPOCH program were reasonable predictors of future performance. These issues are addressed in the present report.

The rest of this appendix comprises five sections. Section B.1 describes the data received from SoCalGas Distribution. Included is a discussion of available data for the pilot study area where pipeline repair statistics were analyzed. Section B.2 discusses the development of the pipeline databases. The characteristics of exposed distribution pipelines in the study area are discussed in detail. Section B.3 reviews the current SoCalGas Distribution procedure for estimating future corrosion leaks and tests it with data collected in the pilot study area. Section B.4 presents an alternate corrosion prediction model that incorporates the age of first leak as a model parameter. The results show that the inclusion of this new parameter in the development of corrosion prediction models increases the number of cases in which corrosion predictions can be made. Finally, the major conclusions of this study are presented along with recommendations to further improve corrosion prediction modeling for all of SoCalGas's distribution pipelines.

B.1 DATA RECEIVED FROM SOCALGAS

Data received from SoCalGas may be divided into two categories: general system information, and information specific to the Torrance study area.

B.1.1 System Information

A review of general system information was performed to determine the relation of the small study area to the overall system. The primary source of piping information was a 1986 Engineering Department report entitled "Underground Piping System Replacement Assessment". Included in this report is a piping system breakdown by pipeline family, summarized for non-service facilities in Table B-1.

Table B-1 SoCalGas Pipe Families (Not Including Services)

Pipe Material	Coating	Installation Era	Cathodic Protection	Length of Pipe (Miles)	Length of Pipe (Kms)	%
Steel	Bare	Pre-1936	Not Specified	2,285	1,420	6.3
		Post-1936	Unprotected	2,897	1,801	8.0
		Post-1936	Protected	173	108	0.5
	Coated	1936-1949	Not Specified	4,585	2,850	12.6
		1949-1971	Unprotected	4,830	3,002	13.3
		1949-1971	Protected	9,780	6,078	26.9
		Post-1971	Protected	3,625	2,253	10.0
Plastic				8,050	5,003	22.2.
Copper				60	37	0.2
Cast Iron				58	36	0.2
TOTAL MAINS				36,343	22,588	

B.1.2 Torrance Study Area Data

Detailed data for the selected study area within the City of Torrance was provided by Distribution and the South Coastal Division. The study area was limited to five SoCalGas atlas sheets - Torrance 9, 10, 15, 16 and 17. The boundary of the study area is shown on Figure B-1. For each of these atlas sheets, the following mapped information was collected:

- atlas sheets indicating pipeline material, diameter, date of installation, cathodic protection (CP) and pressure

- leak history maps (scale: 1 inch = 100 feet), which indicate the location and date of repairs attributed to corrosion, material failure, and construction defects. (The notation of mechanical leak repairs is optional.) This map set is updated upon pipe replacement by physically covering previous information by fastening a xerox of the revised atlas sheet pipe section directly to the history map.

- records of recent leak detection surveys

In addition to the mapped information, the SoCalGas Leak Repair Order (LRO) database for the 5 listed atlas sheets was provided. The LRO database covers the years 1970 through 1992, and includes the repair location, leak code, leak cause, repair date, and miscellaneous pipeline information (diameter, material, year of installation, main/service, etc.). A total of 491 main leaks are listed for the 5 subject atlas sheets.

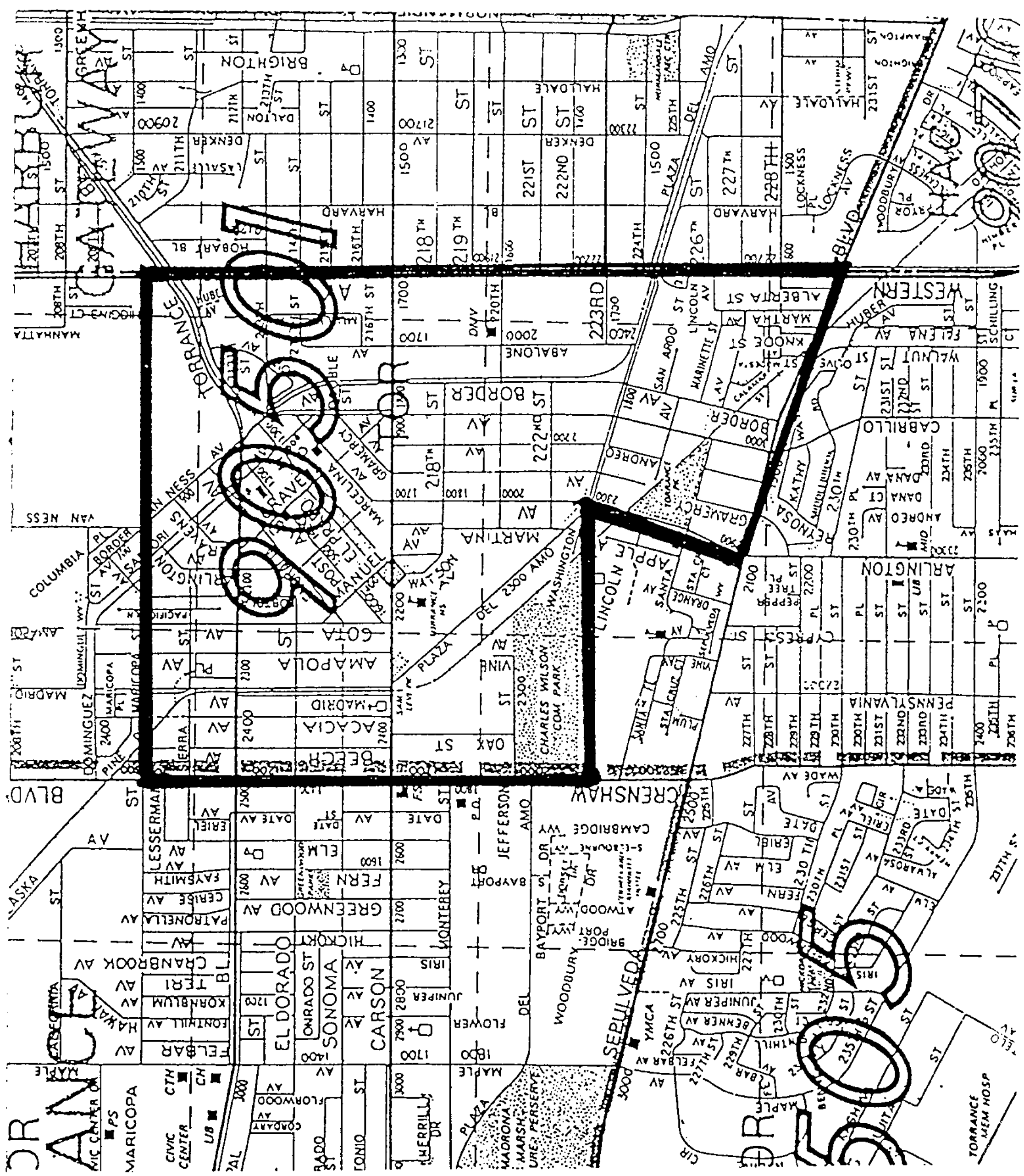


Figure B-1: Torrance Study Area

B.2 ANALYSIS OF TORRANCE AREA DATA

The analysis of the Torrance study area required the development of two complimentary databases; a pipeline segment database and a segment leak database. The correlation of the two data sets allows for the comparison of pipe leakage according to material, diameter, age, and unit length.

B.2.1 Development of Pipeline Segment Database

For each atlas sheet, individual pipeline segments were defined to be homogeneous with respect to pipeline diameter, material, cathodic protection, and age. That is, a change in material or diameter would be reflected by the definition of a separate segment. Only mains were included (i.e., no service pipe), and pipe coating was not part of the data available from the collected information. For each segment, the total length in feet was scaled from the leak history maps. Small index maps identifying pipeline segment names and locations, as well as a printout of the pipeline segment database are provided in Appendix C.

A total of approximately 20 miles (32.2 kms) of main are located within the study area - 26% plastic, 27% steel without CP, and 47% steel with CP. Detailed descriptions of each pipe group are as follows:

- The plastic pipe in use in this area is primarily 2 inches in diameter. All plastic piping was installed after 1978.

- Two-thirds of the steel pipe that is currently not under CP was installed prior to 1936. The remainder was installed prior to 1971, when it became the company standard that all steel pipe should be coated, and put under CP within one year of installation.

- Half of the steel pipe with CP was installed prior to 1971, but information detailing when the segment was actually put under CP was not among the available data, and may be some time after installation.

- While no specific coating information was available for the pipelines in the Torrance area, some generalizations may be made according to historic installation practices (Strang, 1986). Pipe installed prior to 1936 may be assumed bare. All steel pipe installed after 1971 are required to be cathodically protected. According to SoCalGas data, approximately 82% of steel mains in place, as of the end of 1992, are coated, while the remaining 18% are bare (SoCalGas Annual Report for Calendar Year 1992). (The majority of this uncoated pipe is not cathodically protected.) For installation between the years of 1936 to 1941, and after 1958, the coated pipe may be assumed to have a "good" coating, while those put in place between the years of 1942-1957 may be considered to have "poor" coating (Strang, 1986).

The distribution of pipe types within the study area may be compared to system-wide statistics to determine if the selected study area is a representative sample.

- System-wide, 35% of all mains are plastic. Within the Torrance study area, 26% of mains are plastic.

- The Torrance study area has a higher percentage of steel pipe under cathodic protection than the system average. Approximately 56% of steel pipe is under cathodic protection system-wide (SoCalGas, 1992), while within the Torrance area, about 63% of the steel pipe has CP.

- The study area has a higher percentage of older and newer steel pipe than the system average. Overall, most of the system (79%) was installed between 1936 and 1970 (Strang, 1986), while that percentage for the study area is 48%. 8% of all SoCalGas steel mains were installed prior to 1936 vs. 26% of the steel pipe in the Torrance study area. Similarly, 13% of the system was installed in 1971 or after (Strang, 1986), vs. 26% for the study area.

B.2.2 Leak Assignments

Having identified pipeline segments and their characteristics, it was necessary to associate leak repairs as reported in the LRO database with individual pipeline segments. This required physically locating each repair in the LRO database on the leak history map or atlas sheet, according to address or location. This task was facilitated through the use of address map book pages from the City of Torrance, indicating street addresses for various lots. Verification of leak assignments made on the basis of location was possible, to some extent, through cross-referencing of pipeline data tabulated in the LRO database. For example, if the LRO location was an intersection containing two perpendicular pipes, assignment could usually be made by matching the pipe diameter or installation date in the LRO database with the same information in the pipeline segment database. In this way, virtually all main leaks were associated with an individual pipeline segment. A printout of this leak database is provided in Appendix D.

Of the 491 main leaks indicated in the LRO database, 32 were unlocatable. For some of these repairs, the address/location was a vague description, and the local pipes were similar enough to make a definitive assignment impossible. In other cases, repair addresses were physically on a different atlas sheet not included in the study area. Of the remaining 459 leaks, 70% (322 leaks) were attributed to corrosion, 1% (5 leaks) to material failure, and 2% (8 leaks) to construction defects. An additional 19% (88 leaks) were classified as "other" causes. This category includes mechanical leaks such as thread leaks. The remainder were classified as "outside or third party damage" (2%) or "unknown" causes (6%) which includes cases of repair or replacement when the leak itself was not physically exposed.

Because the LRO data included all leak repairs made between the years of 1970 and 1992, it was possible to determine pipe characteristics for pipeline segments that were subsequently replaced. For example, a pipeline segment replaced in 1986 will likely have its history concealed on the leak history map, but the LRO for years prior to 1986 will indicate the pipeline material, diameter and original installation date. This information was used to determine the "previous" pipe information for various pipeline segments, and allowed the "previous" pipeline segments and their leaks to be included in the leakage analysis. This information is included in the pipeline segment database in Appendix C.

B.2.3 Summary of Corrosion Leakage Data

Steel pipeline segments may be grouped into various categories, as follows:

- A) Steel pipe under CP
- B) Steel pipe without CP, installed pre-1936 (considered bare)
- C) Steel pipe without CP, installed between 1936 and 1971 (predominantly coated)
  - C1) 1936 - 1940, and 1958 - 1970 - "good" coating
  - C2) 1941 - 1957 - "poor" coating

For the steel pipe, The majority of the 322 corrosion repairs recorded in the LRO were assigned to Category B pipe (278 repairs, or 86%), making this data set the most suitable for detailed analysis. The remainder were distributed as follows;

- Category A - 24 repairs (7%)
- Category C2 - 15 repairs (5%)
- Category C1 - 5 repairs (2%)

B.2.4 Comparison of LRO Data to the Leak History Maps

By physically plotting all listed repairs onto the leak history maps, it was possible to assess the completeness of the data as plotted by SoCalGas. According to SoCalGas personnel (personal communication with Mr. Ron Hammer, November, 1992), all repairs of leaks caused by corrosion, material failure, or construction defects should be posted on the leak history maps (leak causes 1 - 3, 9 and 10, respectively in the LRO database). Posting of mechanical or joint leaks is optional (these leaks are included in LRO leak cause 11 - "Other").

To make a comparison between the history maps and the LRO database, only those pipeline segments whose history for the years 1970 to 1992 is visible on the leak history maps may be used. That is, only segments that were not replaced during that time period, and have not had their leak history concealed are included. Of the 322 corrosion leaks included in the LRO database, 178 are on pipeline sections with visible history. Approximately 66% of these repairs were actually plotted on the maps by SoCalGas. Percentages according to leak code are as follows:

- approximately 58% of all Code 1 leaks on visible sections were noted on the map,
- approximately 69% of all Code 2 leaks, and
- approximately 68% of all Code 3 leaks.

While few of the repairs within the LRO database were caused by construction defects or material failure, virtually none of the these repairs were indicated on visible segments. In addition, it appears that only 17% of repairs due to "other" causes on visible segments are plotted (plotting of these repairs is optional).

It is possible, therefore, that using leak data from the leak history map may provide an incomplete picture of actual segment leakage over time. While the history maps do contain information prior to the 1970 start date of the LRO database, it does not appear that the mapped information is a comprehensive record.

B.2.5 General Approach for Calculating Leak Rates

Cumulative leak rates, or the total number of historic leaks developed by a pipeline segment per unit length, can form the basis for the prediction of future pipeline performance. Using pipeline characteristics and leak data, it was possible to develop cumulative leak rate histories for individual pipeline segments, and alternatively, to group all pipe of a particular category together to develop a "system" leak rate curve for that pipe class. Leak rates were developed according to pipe age at the time of leak occurrence. For the system analysis, pipe and associated leaks were aggregated according to the categories listed in Section B.2.3.

B.3 ASSESSMENT OF SIMPLE LINEAR REGRESSION APPROACH FOR LEAK PREDICTION

Currently, the repair/replace decision-making program utilized by SoCalGas includes the ability to predict future leakage from available pipeline data. Historical leakage data is taken from the leak history maps, and a standard least squares fit of the data is used to project future leakage on individual pipeline segments. This section discusses the method used to test the validity of this approach.

B.3.1 Test Method

To test the validity of a simple linear regression model for pipeline leakage, the following procedure was used:

- Historical leakage from the LRO database was used. This database is considered to be more comprehensive for post-1970 data because no data is lost during the map update process. The database was segregated into two data sets: data through 1986, and post-1986 data.

- A simple linear regression was performed on the data set through 1986. Cumulative leak rates (cumulative leaks per 1,000 feet of pipe) for individual pipeline segments were plotted versus pipeline age. A "best-fit" line was developed to predict subsequent leakage.

- Actual post-1986 performance was plotted and compared to predicted performance.

For the pre-1936 steel pipe data set (accounting for 86% of all corrosion leaks in the LRO database), 10 non-replaced segments had sufficient data to be included in the assessment. To be included, pipeline segments had to meet three critical requirements: 1) the segment must not have been replaced, 2) the segment must have sufficient data through 1986 to perform a linear regression (at least 2 years with reported leakage), and 3) actual post-1986 leakage data must exist to compare to the prediction. Figures B-2 through B-5 present the test results for the 10 segments, in three data sets; pipe installed in 1912 (Figures B-2 and

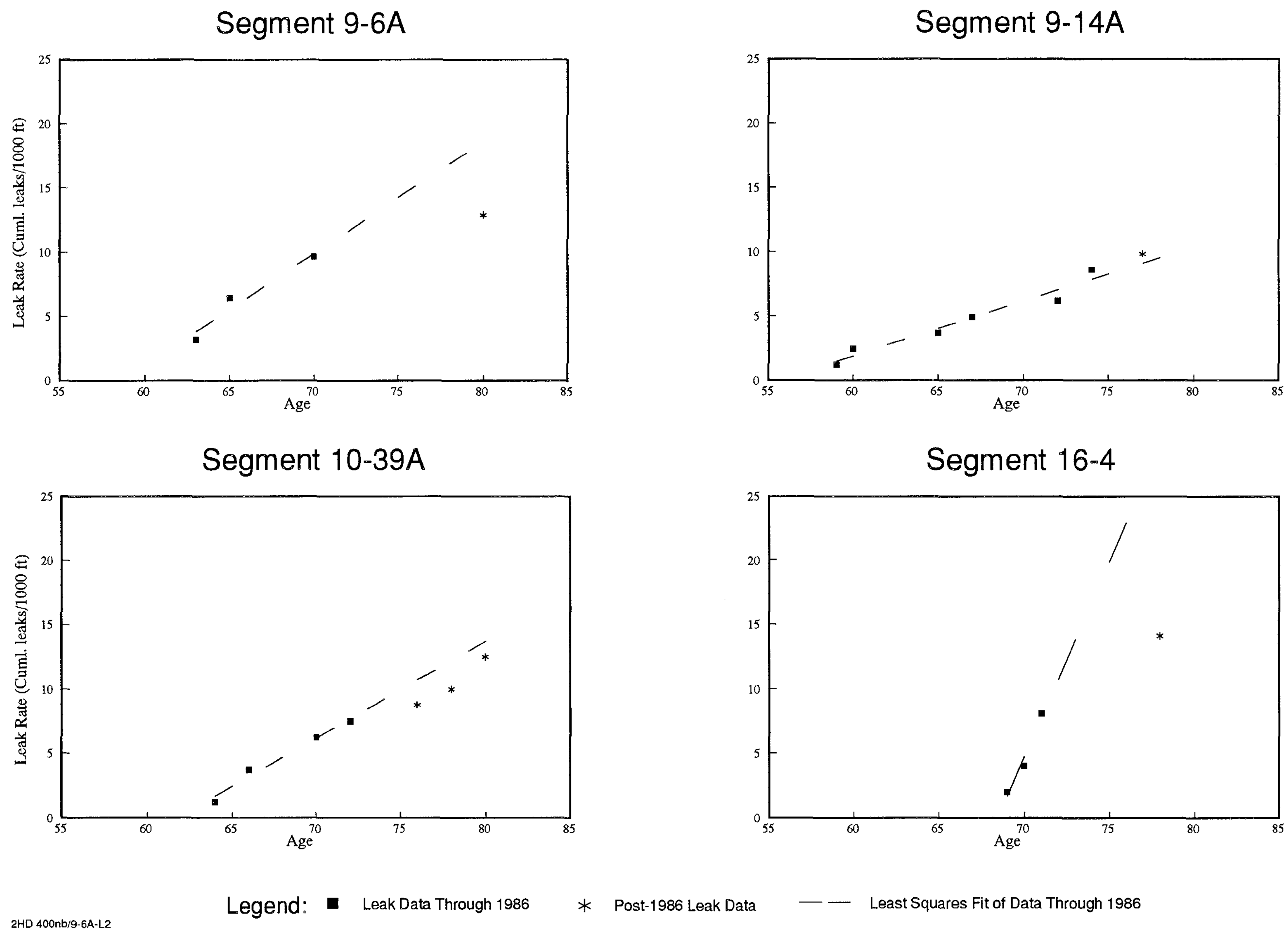
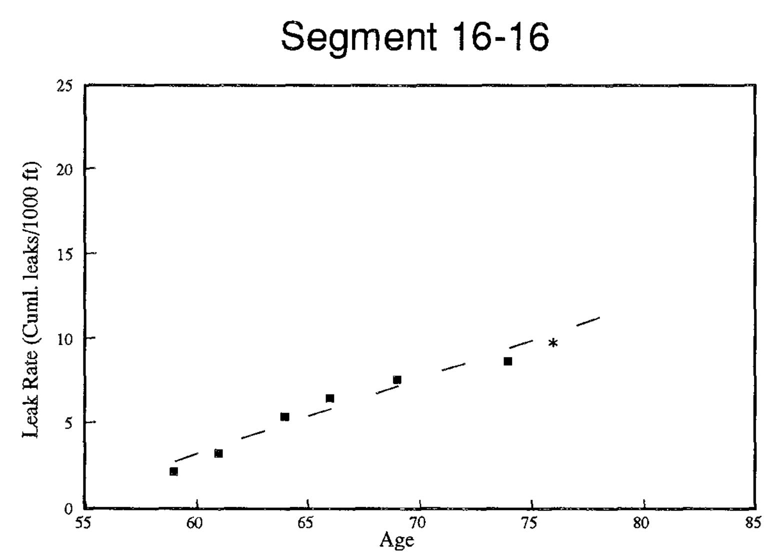


Figure B-2: Comparison of Leak Rate Prediction from Linear Regression of Data through 1986 to Actual Post-1986 Performance (Pipe Installed in 1912)



Legend: ■ Leak Data Through 1986 * Post-1986 Leak Data — — Least Squares Fit of Data Through 1986

Figure B-3: Comparison of Leak Rate Prediction from Linear Regression of Data through 1986 to Actual Post-1986 Performance (Pipe Installed in 1912)

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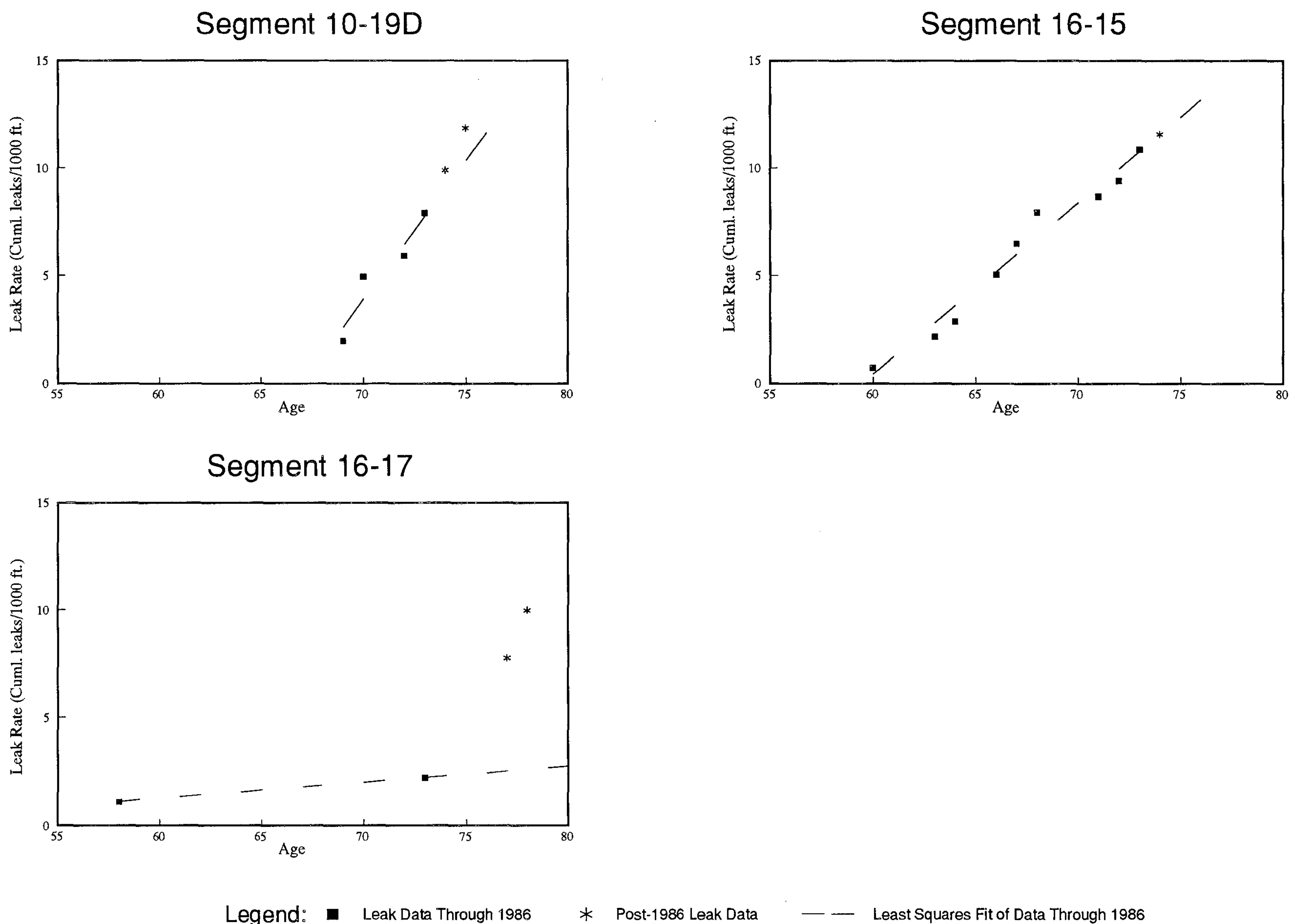

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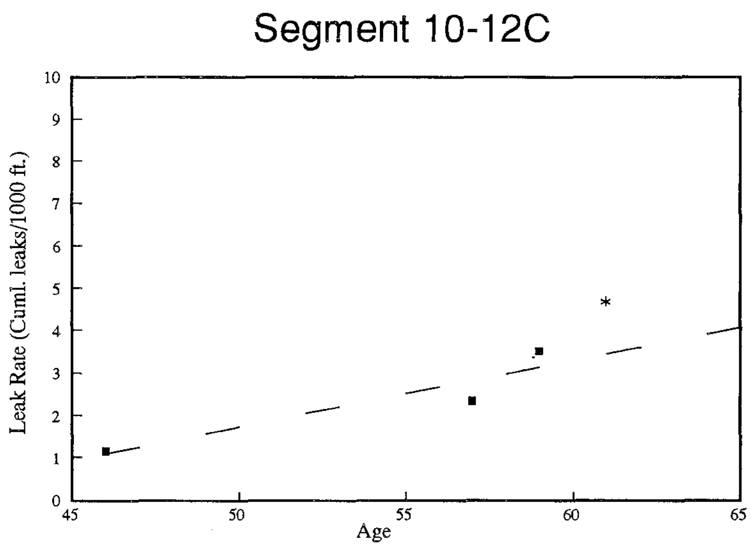
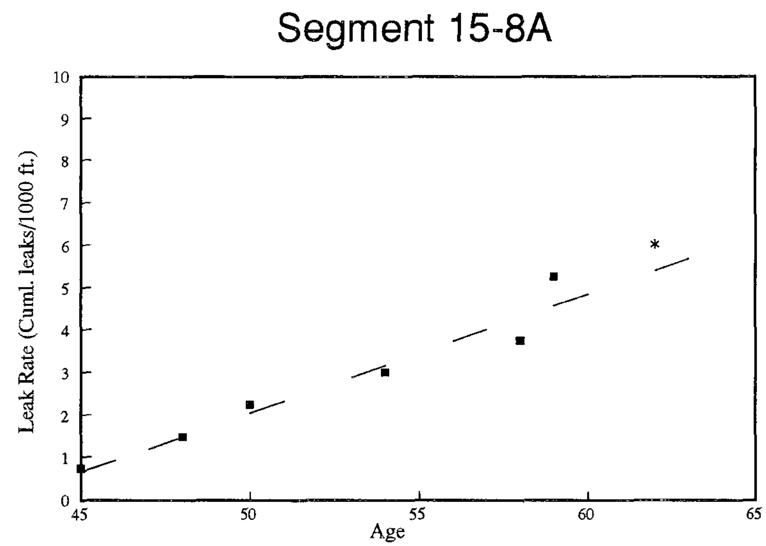
Figure B-4: Comparison of Leak Rate Prediction from Linear Regression of Data through 1986 to Actual Post-1986 Performance (Pipe Installed in 1913)





Legend: ■ Leak Data Through 1986 ✻ Post-1986 Leak Data — — Least Squares Fit of Data Through 1986

Figure B-5: Comparison of Leak Rate Predictioin from Linear Regression of Data through 1986 to Actual Post-1986 Performance (Pipe Installed in 1927)

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B-3), 1913 (Figure B-4) and 1927 (Figure B-5). These three pipe categories represent roughly 60% of all non-replaced pre-1936 steel pipe. (The remaining 40% is divided among 14 different installation years.)

B.3.2 Results

As shown in the figures, the linear regression technique is a good predictor of actual performance when sufficient data exists (i.e., more than three data points), but the accuracy tends to decrease with decreasing data. For the 10 sample segments, 50% of the predictions at the age of last recorded post-86 leak were within 10% of the actual performance. Figure B-6 presents the distribution of the difference between predicted and actual performance for the straight line regression technique. It should be noted, however, that only pipeline segments with leakage in at least two years are included in this prediction assessment. No prediction can be made for segments with only one leak.

B.3.3 Strengths and Weaknesses of Simple Linear Regression Model

Strengths and weaknesses of the linear regression approach may be summarized as follows:

Strengths:

- With sufficient data, the linear regression model provides a good predictor of future pipeline leak rates.
- By incorporating each individual segment's leakage history in the analysis, it is possible to include localized factors that might influence leak rates.
- The method is simple to develop and easy to use.

Weaknesses:

- This method can not predict future performance based on limited data (i.e., 1 data point).
- Accuracy decreases with fewer data points.

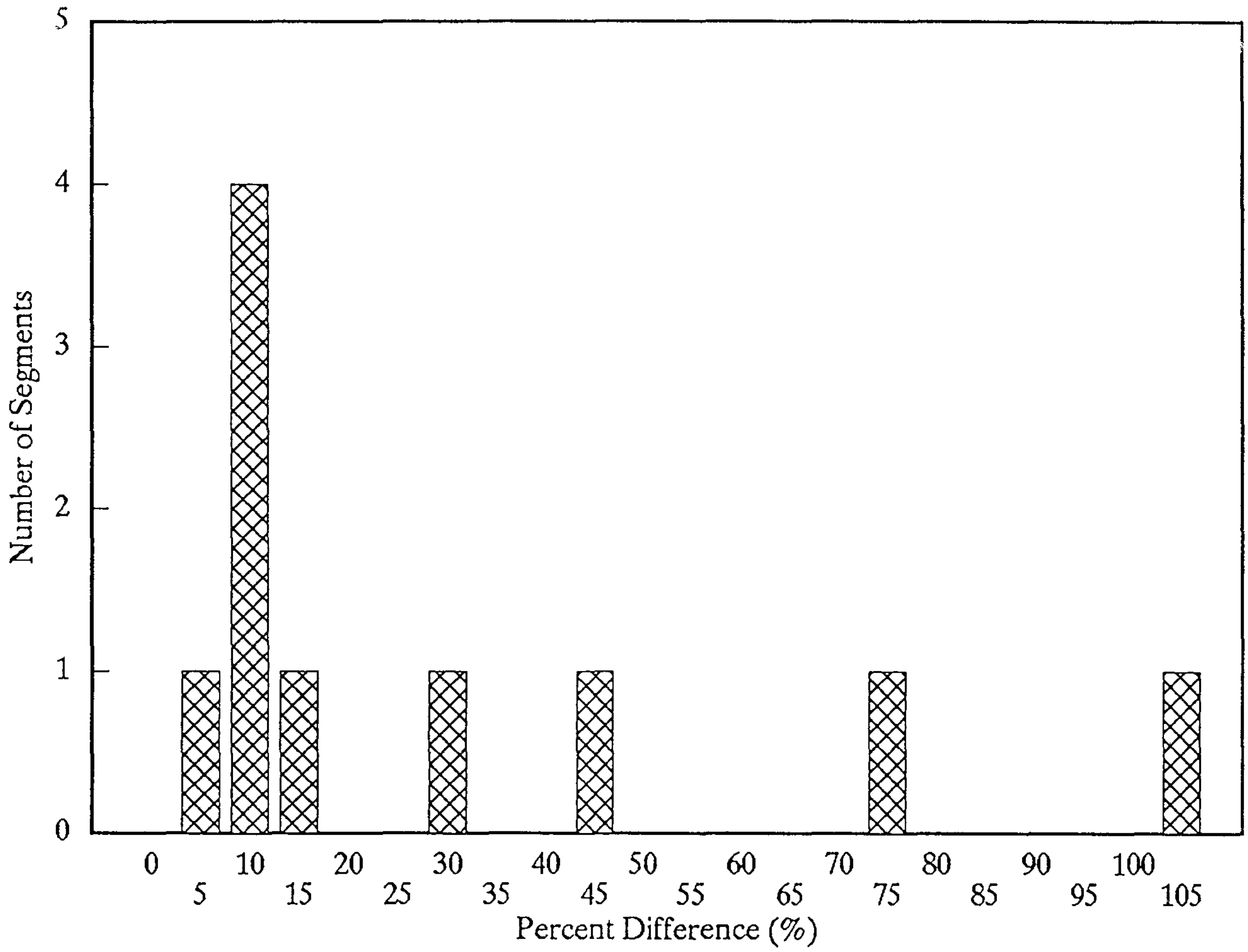

Figure B-6: Percent Difference Between Predicted and Actual Leak Rates using Simple Linear Regression techniques

- A least squares regression model developed from data on the leak history maps may not include all available data, and accuracy of prediction may be reduced.

B.4 DEVELOPMENT OF ALTERNATIVE LEAK PREDICTION METHODOLOGY: AGE DEPENDENT MODEL

Because the simple linear regression approach had several weaknesses, the possibility of developing a supplemental approach to leak prediction based on available data was explored. A variety of approaches were taken, and an alternative leak prediction model was developed. This section describes the development of the supplemental "age dependent" model. In this particular context, age is defined as the age of the pipe at the first observed leak. Note, that the database used in this study begins in 1970; therefore, it is possible that earlier leaks (before 1970) occurred which were not included in this analysis.

B.4.1 Development of the System Curve

For all pre-1936 steel pipe, the total number of leaks, and the age at which they occurred were tabulated using the 1970 - 1992 LRO data. Similarly, the total amount of pipe of a particular age in the ground was determined. For example, a steel pipeline segment installed in 1913 would contribute to the appropriate steel family for ages 57 - 79. If listed repairs occurred in 1975, 1980 and 1984, these leaks would contribute to ages 62, 67, and 71. Pipe that was replaced at some point during the 22 years of detailed data must be treated somewhat differently. In order to reflect the fact that the pipe is removed from the ground, the corresponding data must also be removed from the database. If the example pipe referenced above was replaced in 1986, its length would only contribute through age 73. In addition, its leaks must also be removed following replacement.

Figure B-7 presents cumulative leak rates versus age for replaced and non-replaced pre-1936 steel pipe without catholic protection. As is evident in the figure, the trends reflected by the two categories of pipe are quite different. For the replaced pipe, the trend reflects a series of upward and downward slopes. In large part, the downward trends are attributed to pipeline replacement, and associated removal of data. In addition, the initial cumulative leak rates for replaced pipe (i.e., for ages 45 to 55) are higher than those for non-replaced pipe for the same age range.

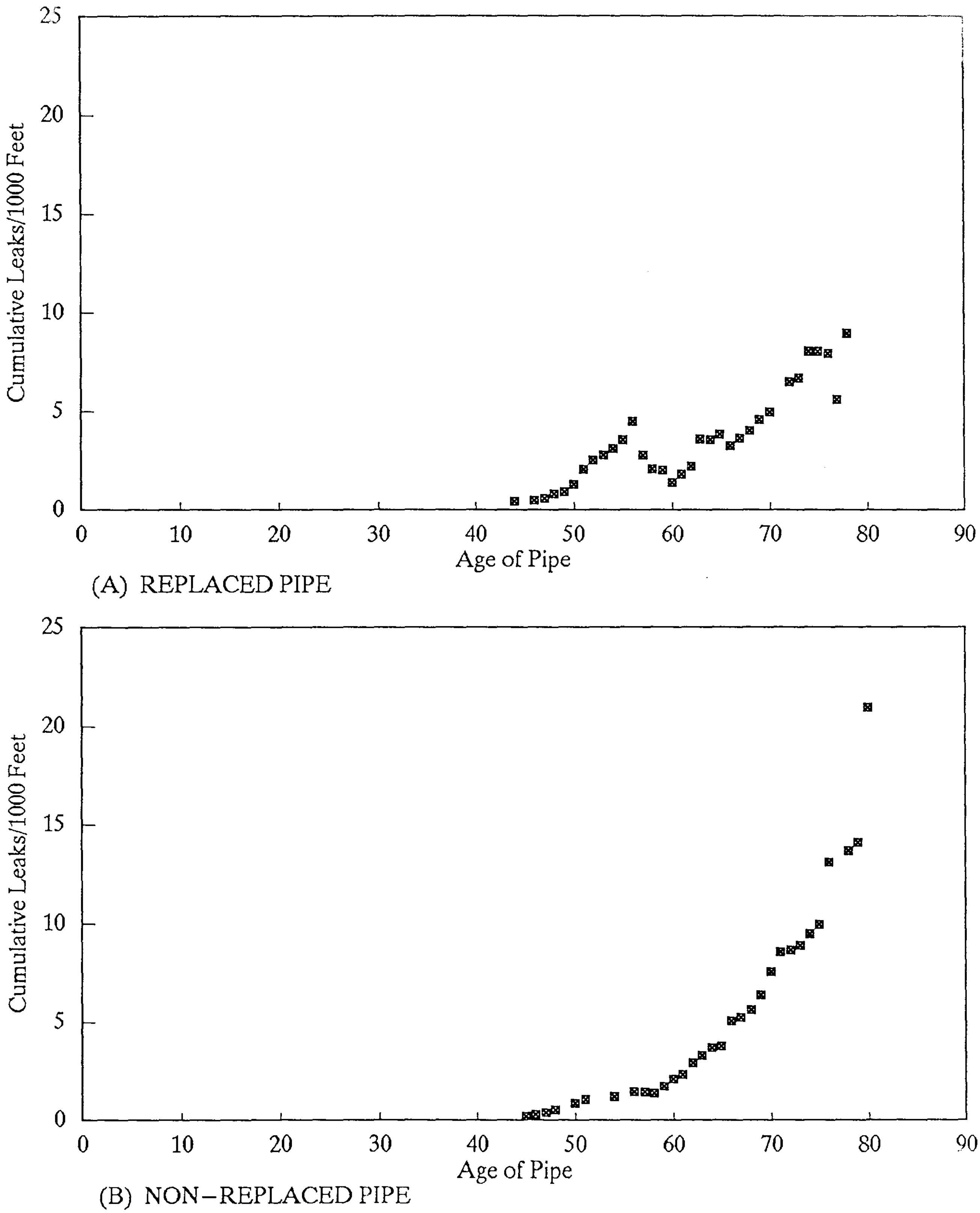

Figure B-7: Cumulative Corrosion Leak Rates for Pre-1936 Steel Pipe without Cathodic Protection

According to discussions with SoCalGas personnel, some types of steel pipe experience rapid increases in repair rates, even at fairly young ages. Because of these high rates of initial repair, these pipelines were replaced even though the pipes were quite young. Since the focus of this particular study is to develop methods to identify when to repair and when to replace pipe based on long-term data, it was decided to exclude the replaced pipe information. The decision to replace pipe with extremely high repair rates usually does not require a sophisticated cost-benefit analysis. Where cost-benefit analysis can play a meaningful role is in deciding whether replacement will offset long-term repair costs.

It is important to note that the combination of the two curves in Figure B-7 reflect the total performance of pre-1936 steel pipe in this particular area. It is difficult to determine whether the higher slopes in the replaced pipe actually reflect leaks that occurred at earlier pipe ages since the data set that was used in this study only begins in 1970. In order to resolve this issue, i.e., higher slopes at earlier pipe ages, it would be prudent to investigate repair data beginning before 1970, and perhaps data from other parts of the system.

It may be possible that the trends observed in this study are unique to this particular service area. Therefore, before the models can be used for other areas, more analysis would have to be performed to justify the current trends and to determine whether they are system wide. This particular recommendation should be implemented only if SoCalGas personnel find the ability to estimate future leak rates based on one or two data points important.

Having plotted individual segment performance for the assessment of the linear regression model, it was noted that the slope of the best fit line appeared to increase with increasing age of first leak. That is, it appeared that the rate of increase in leak rate was higher for leaks striking older pipe. Figure B-8 displays individual pipeline segment leakage histories for the ten sample segments plotted with the non-replaced system curve. The general trend appears to be increasing slope with increasing age at first leak.

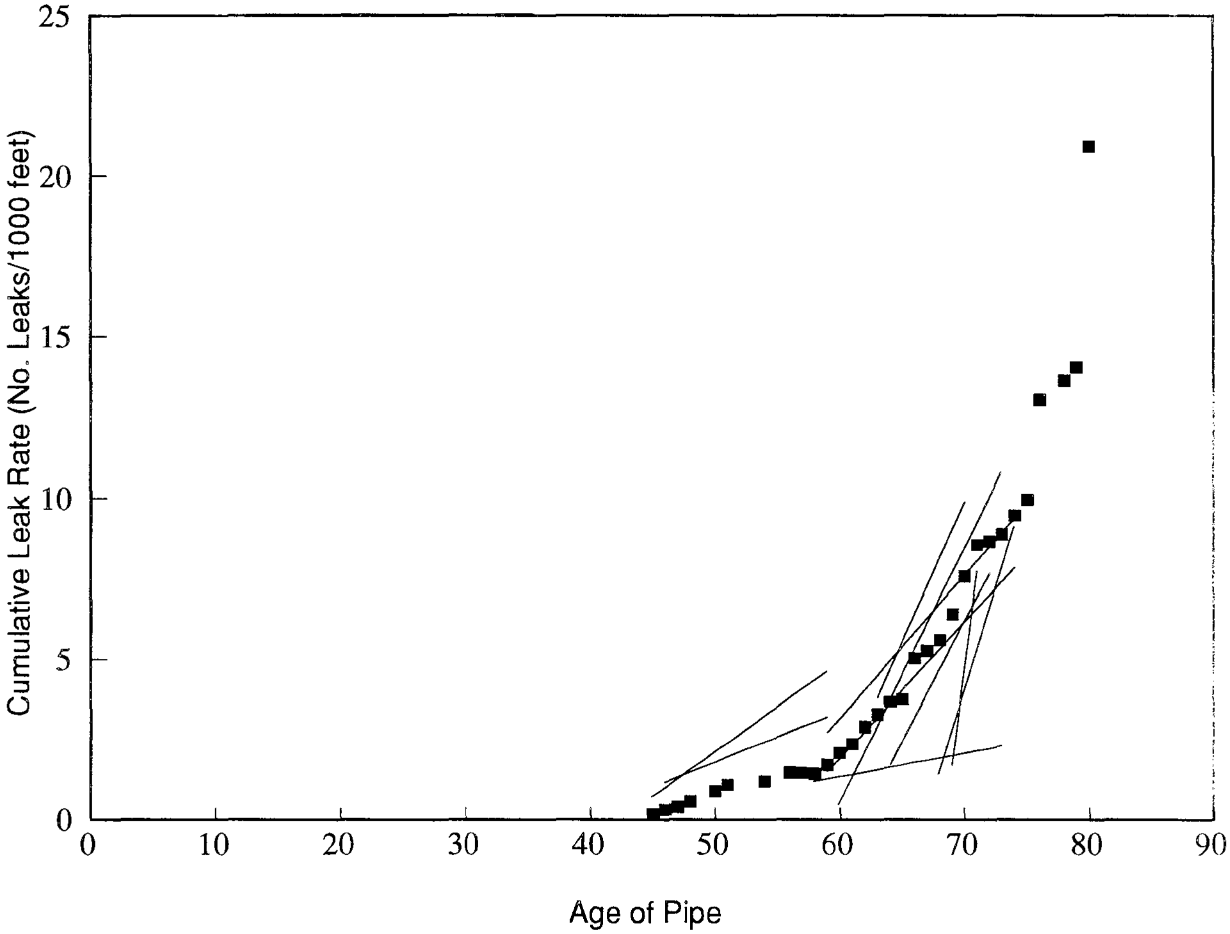

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Figure B-8: Plot of Individual Pipe Segment Leakage Histories on the Cumulative Corrosion Leak Rate Curve

B.4.2 Development of Age Dependent Model

It was clear that the predictive model should capture this variation with age at first leak, as well as reflect differences in installation practices over time. The resulting model relates slope of the leak rate to age at first leak, for pipe installed in various years. For this pilot application, pipe installed in the years 1912, 1913 and 1927 were used to represent pipe in the pre-1936 steel class. (As mentioned before, these sub-classes represent 60% of all non-replaced pre-1936 steel pipe without cathodic protection.)

For each pipeline segment installed in a given year, the slope of the best fit line for leak rate data through 1986 (developed for the linear regression analysis) was plotted against age at first leak. This data appeared to be linear in semi-log space, so a regression analysis was performed to determine the log-linear best fit line. For the 1912 and 1927 data sets, these lines were determined by 5 and 3 data points, respectively. Figure B-9 and B-10 present the resultant leak rate models for these installation years. The 1913 data set produced only 2 data points, which were deemed insufficient to develop a reliable best-fit line. In this case, the data from 1912, 1913 and 1927 were merged into one data set to develop a generalized leak rate model to be used in predictions for the 1913 data. This model is presented in Figure B-11.

B.4.3 Testing of Age Dependent Model

The testing of the age dependent model consisted of two basic tasks: 1) evaluate the performance of the age dependent model for segments with extensive leakage history (for which the linear regression model works well), and 2) evaluate its performance for segments with minimal leakage history (for which no linear regression model can be developed).

B.4.3.1 EVALUATION OF AGE DEPENDENT MODEL FOR SEGMENTS WITH EXTENSIVE LEAKAGE HISTORIES

To test the accuracy of the predictive model for segments with extensive leakage, the same 10 segments used for testing the linear regression model were utilized. For each pipeline segment, the age at first leak was used to determine the slope of the predictor line from the age dependent leak models (Figures B-9 through B-11).

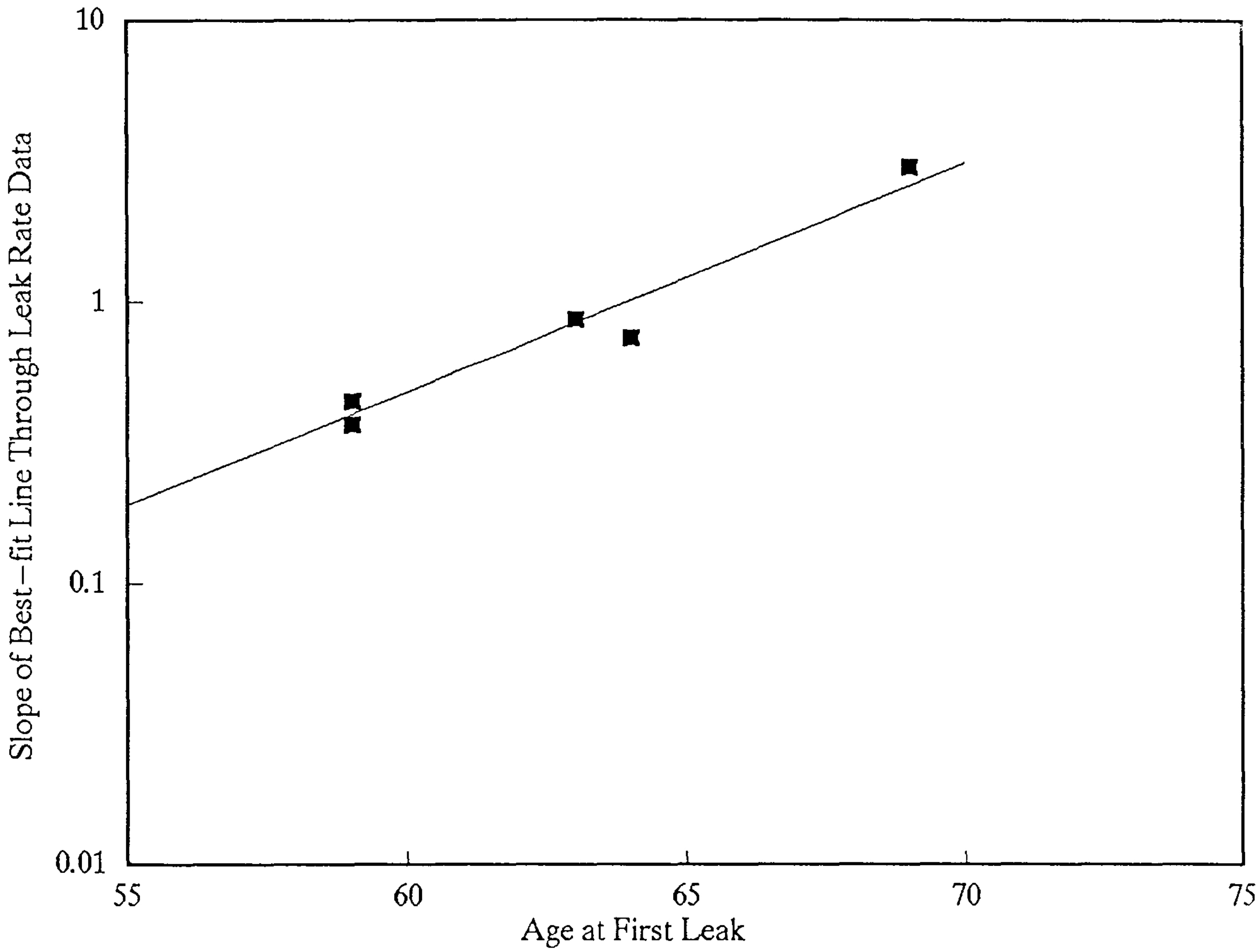

Figure B-9: Age Dependent Leak Rate Model for Steel Pipe Installed in 1912

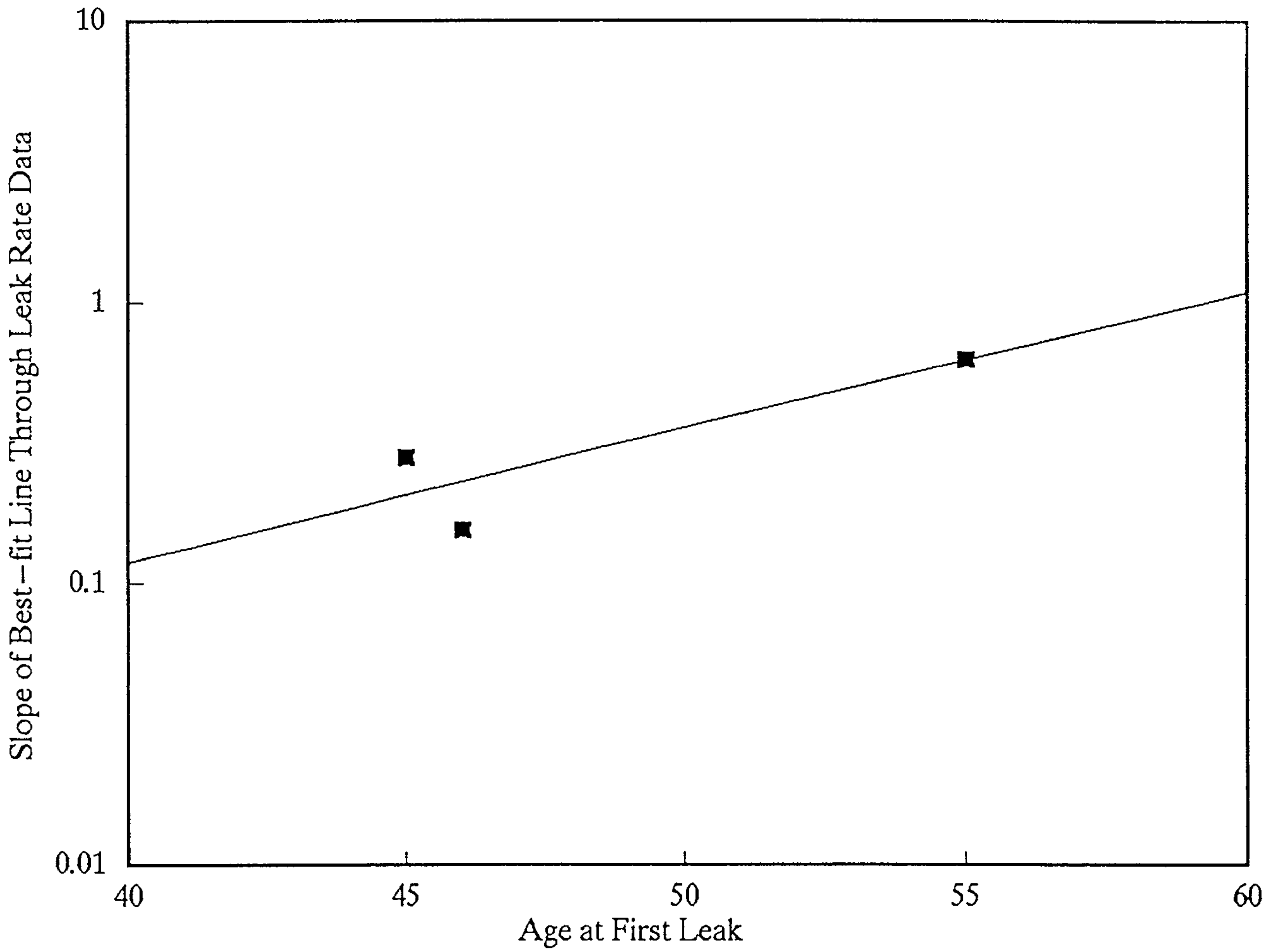

Figure B-10: Age Dependent leak Rate Model for Steel Pipe Installed in 1927

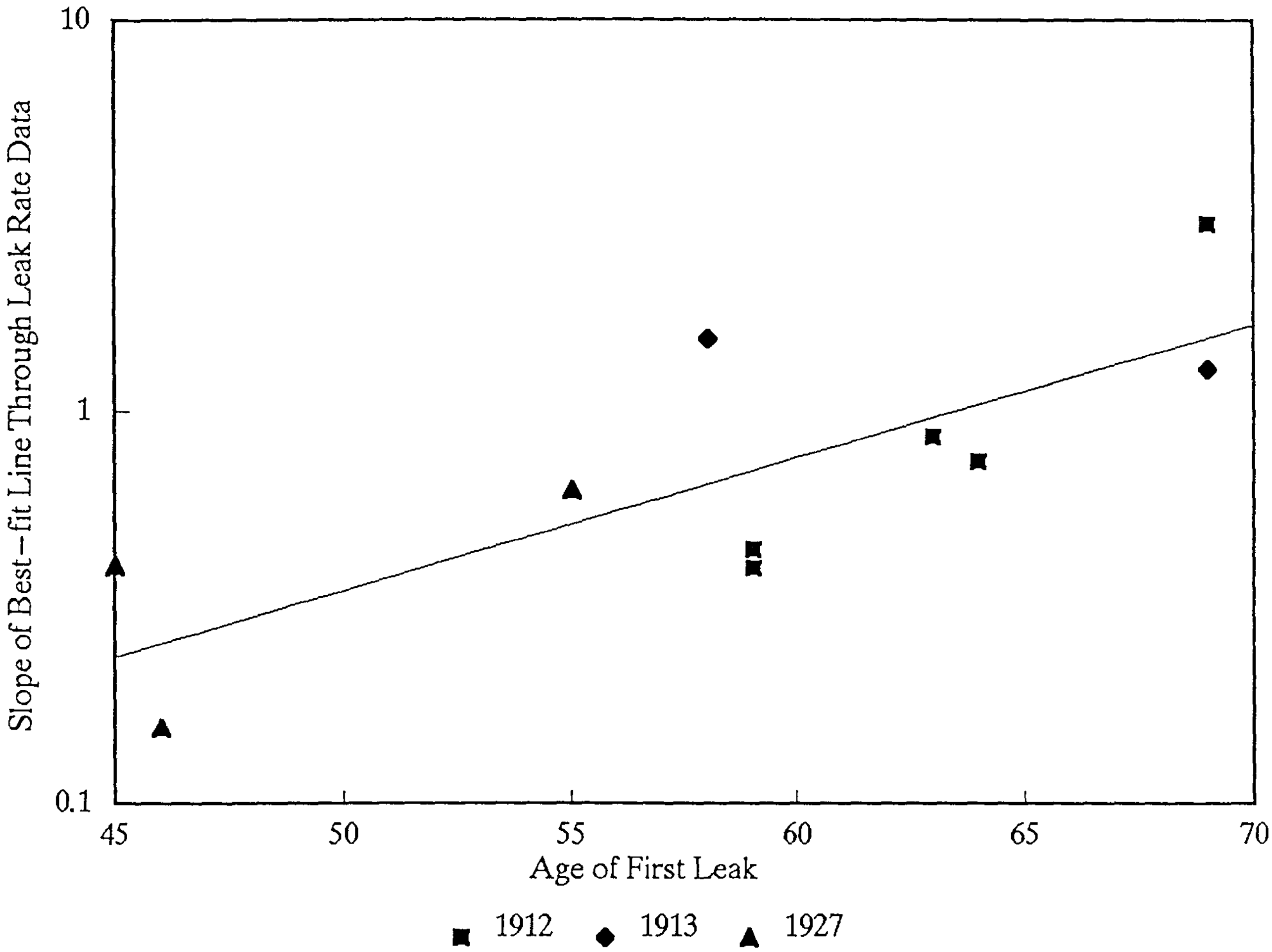

Figure B-11: General Age Dependent Leak Rate Model for Pre-1936 Steel Pipe

From the point of first leak, a line with this slope was drawn. Figures B-12 through B-15 present the results of this evaluation. On each figure, the solid line represents the age dependent model prediction, while the dashed line represents the linear regression prediction.

In most cases, the age dependent model is approximately as good or a better predictor than the linear regression model. The average difference between actual and predicted performance for these 10 pipeline segments is 25.7% for the age dependent model, versus 29.5% for the simple linear regression. Figure B-16 presents the distribution of the difference between predicted and actual performance for both the age dependent model (solid bars) and the straight line regression technique (hatched bars).

B.4.3.2 EVALUATION OF AGE DEPENDENT MODEL FOR SEGMENTS WITH MINIMAL LEAKAGE HISTORIES

While the previous comparison shows that using the age dependent model is roughly equivalent to using the linear regression model, it only applies to pipeline segments with leaks in at least two years. For pipeline segments that have just begun to leak, and have had only one recorded year with leakage, the linear regression technique can not be used to predict future performance, but the age dependent model can. Within the current database, the number of such segments is not insignificant. Figure B-17 shows the distribution of non-replaced pre-1936 steel pipeline segments according to the number of years with leakage (1970 - 1992). As shown in this figure, 45% of the segments could utilize the linear regression model (i.e., 2 or more years with leakage), and 36% have not yet suffered leakage. The remaining 19% have suffered only one leak to date, and could utilize the age dependent model for future leakage prediction.

Six sample segments (installed in 1912, 1913 and 1927) with one leak in the years through 1986, and at least one leak after 1986 have been identified. For these segments, the age dependent model was utilized to predict future leakage. These predictions are shown in Figures B-18 (pipe installed in 1912), B-19 (1913) and B-20 (1927). The results of these predictions are, for the most part, fairly accurate. In fact, in 2/3 of the cases, the predicted leakage is within 15% of actual performance.

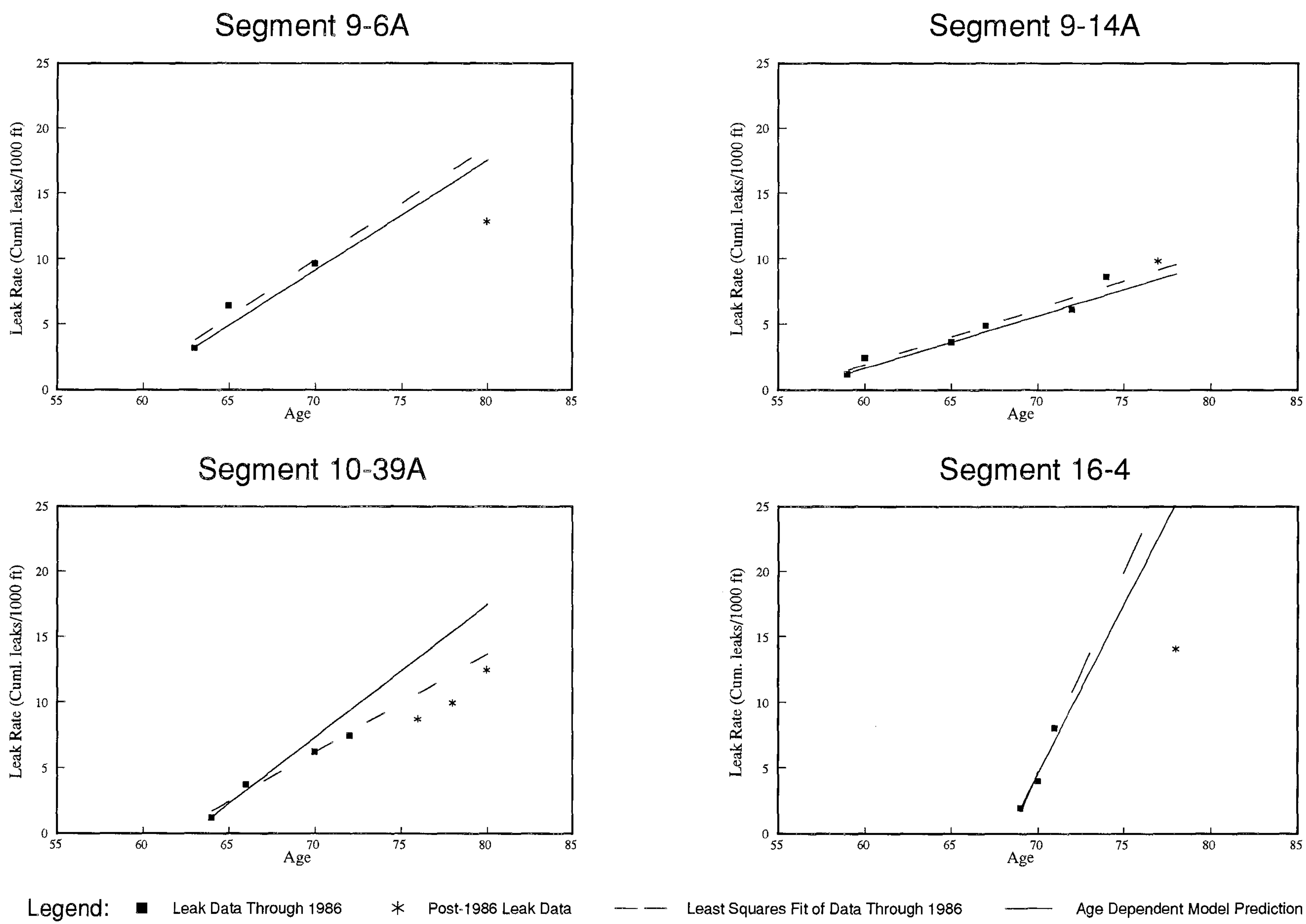

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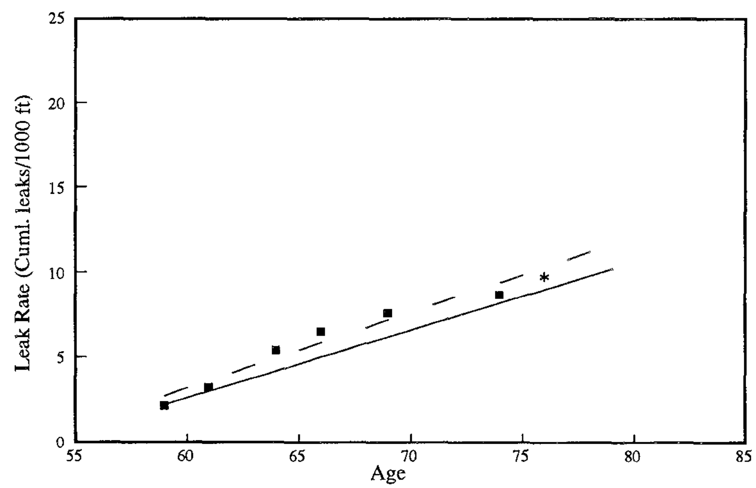
Figure B-12: Comparison of Leak Rates Predicted from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1912)

Segment 16-16



Legend: ■ Leak Data Through 1986 ∗ Post-1986 Leak Data — — Least Squares Fit of Data Through 1986 —— Age Dependent Model Prediction

Figure B-13: Comparison of Leak Rates Predicted from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1912)

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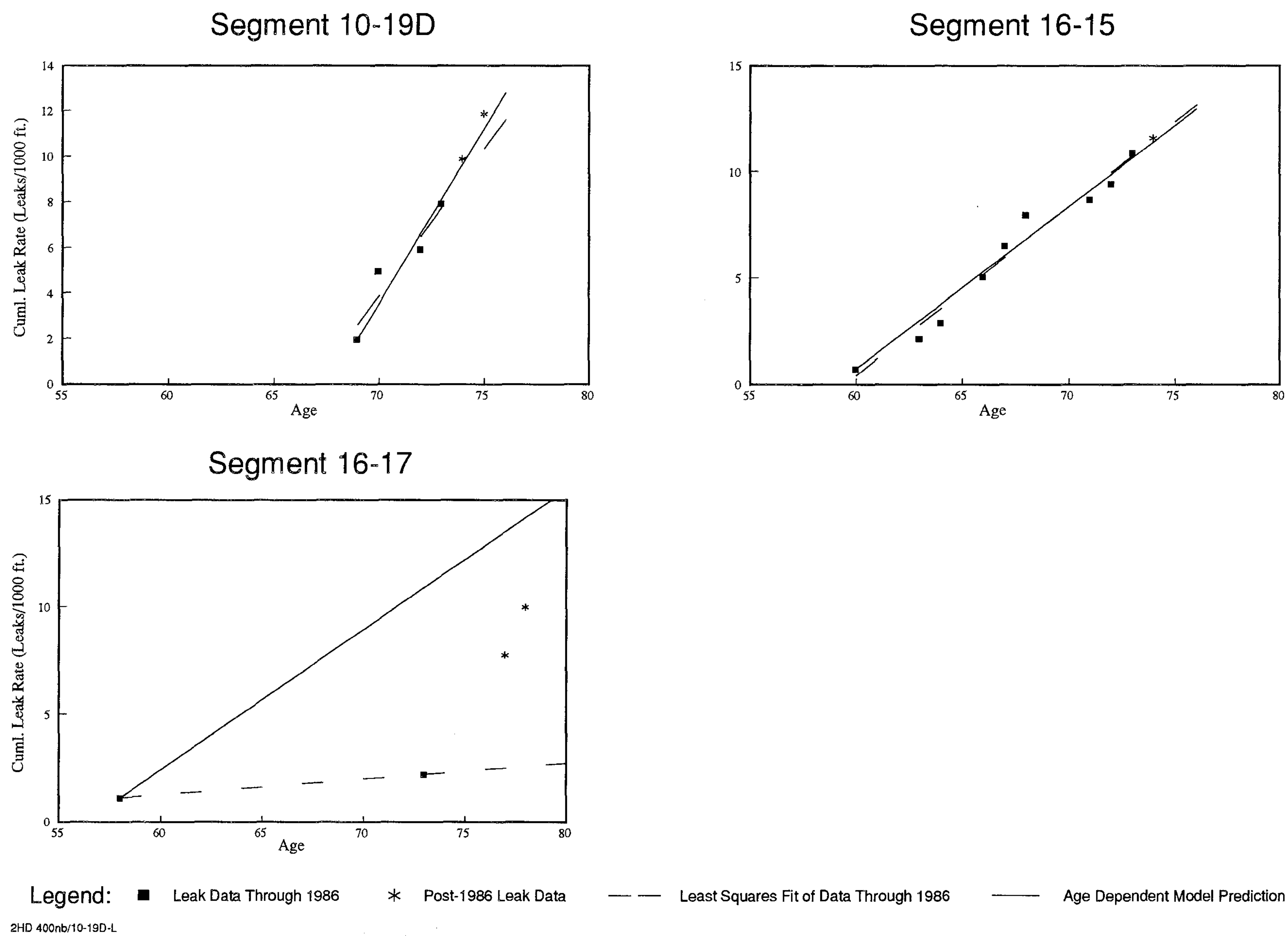
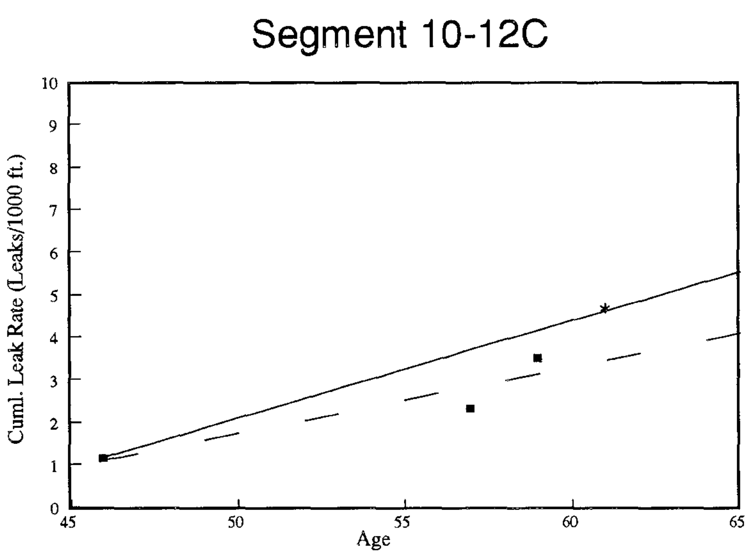
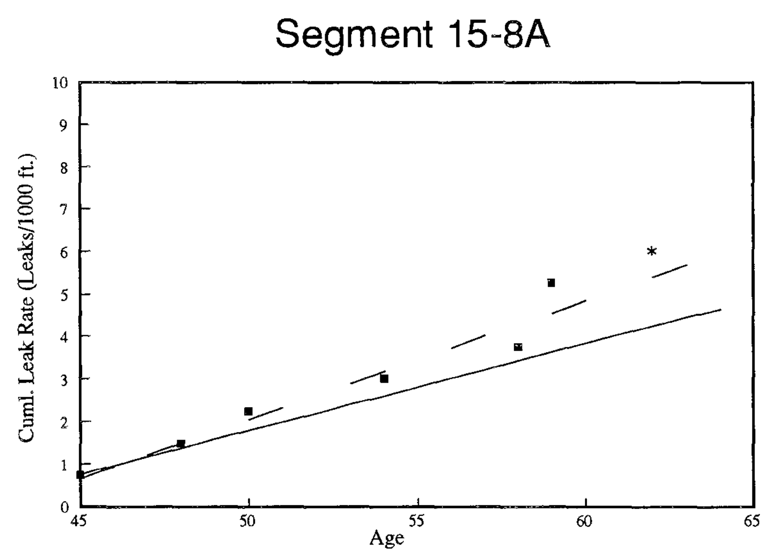


Figure B-14: Comparison of Leak Rates Predicted from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1913)





Legend: ■ Leak Data Through 1986 * Post-1986 Leak Data — — Least Squares Fit of Data Through 1986 —— Age Dependent Model Prediction

Figure B-15: Comparison of Leak Rates Predicted from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1927)

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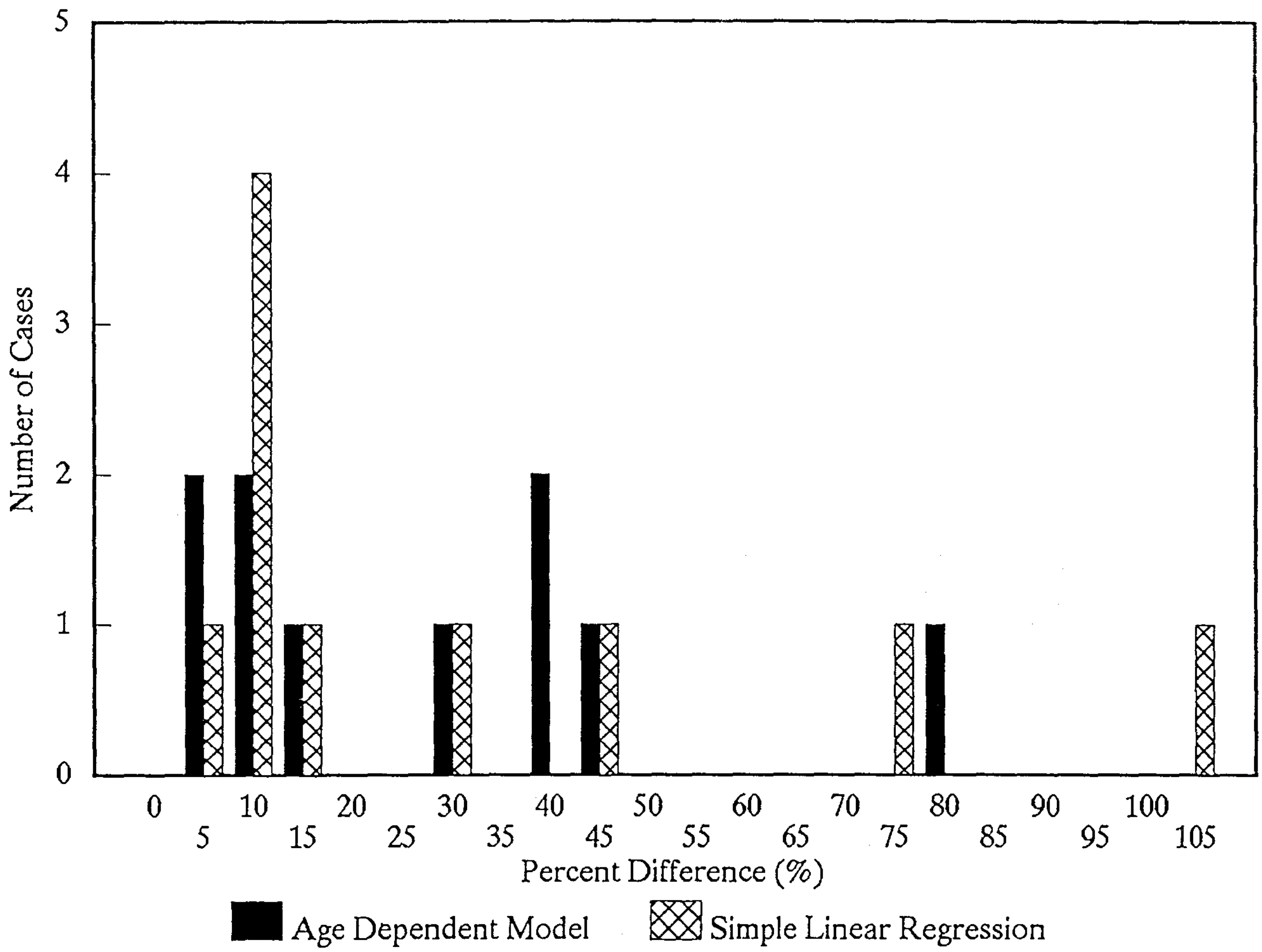


Figure B-16: Percent Difference Between Predicted and Actual Number of Leaks

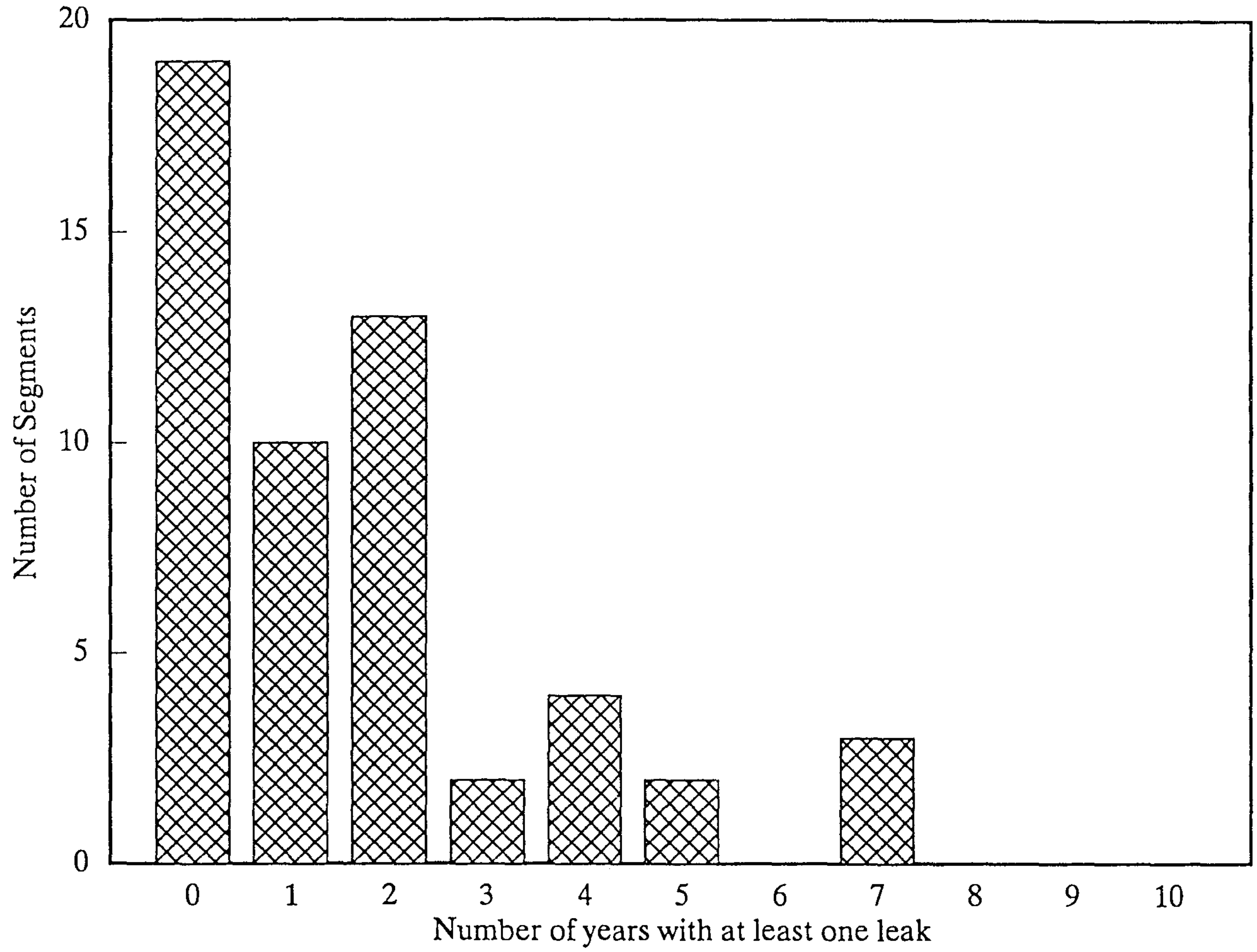
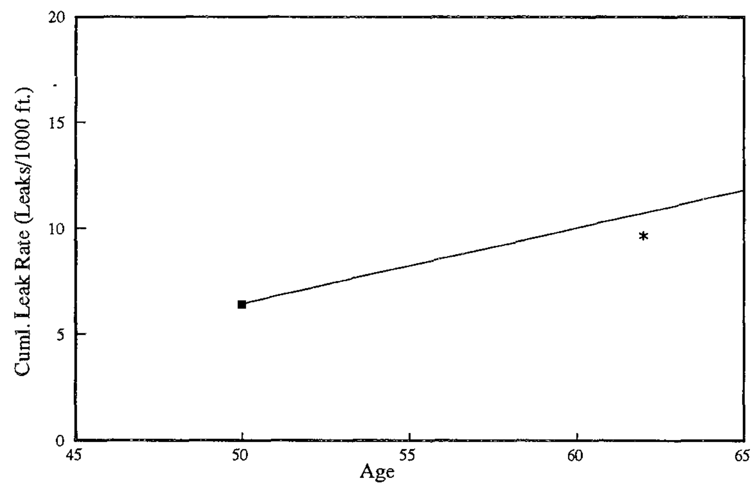


Figure B-17: Distribution of Pipe Segments by Number of Years with Leak Occurrences

Segment 15-3A



Legend: ■ Leak Data Through 1986 ✱ Post-1986 Leak Data ——— Age Dependent Model Prediction

Figure B-18: Comparison of Predicted Leak Rates from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1912 with Limited Leakage)

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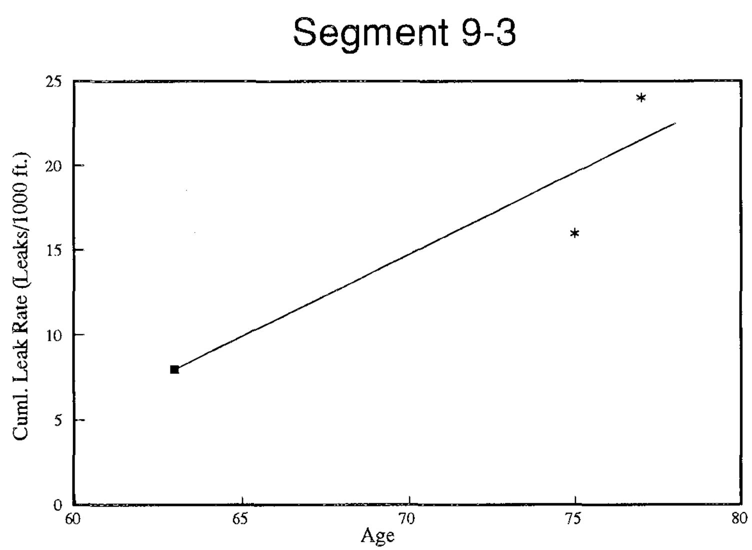

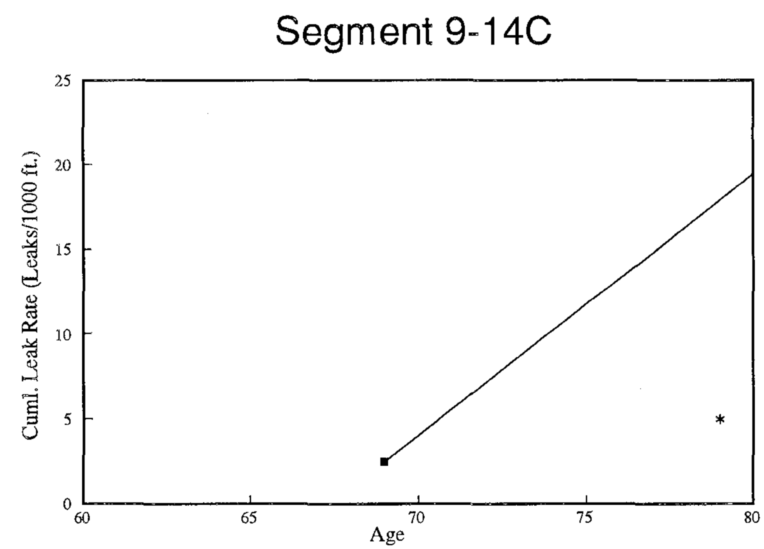

Legend: ■ Leak Data Through 1986 ✳ Post-1986 Leak Data ——— Age Dependent Model Prediction

Figure B-19: Comparison of Predicted Leak Rates from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1913 with Limited Leakage)

2HD 400nb/9-3-R

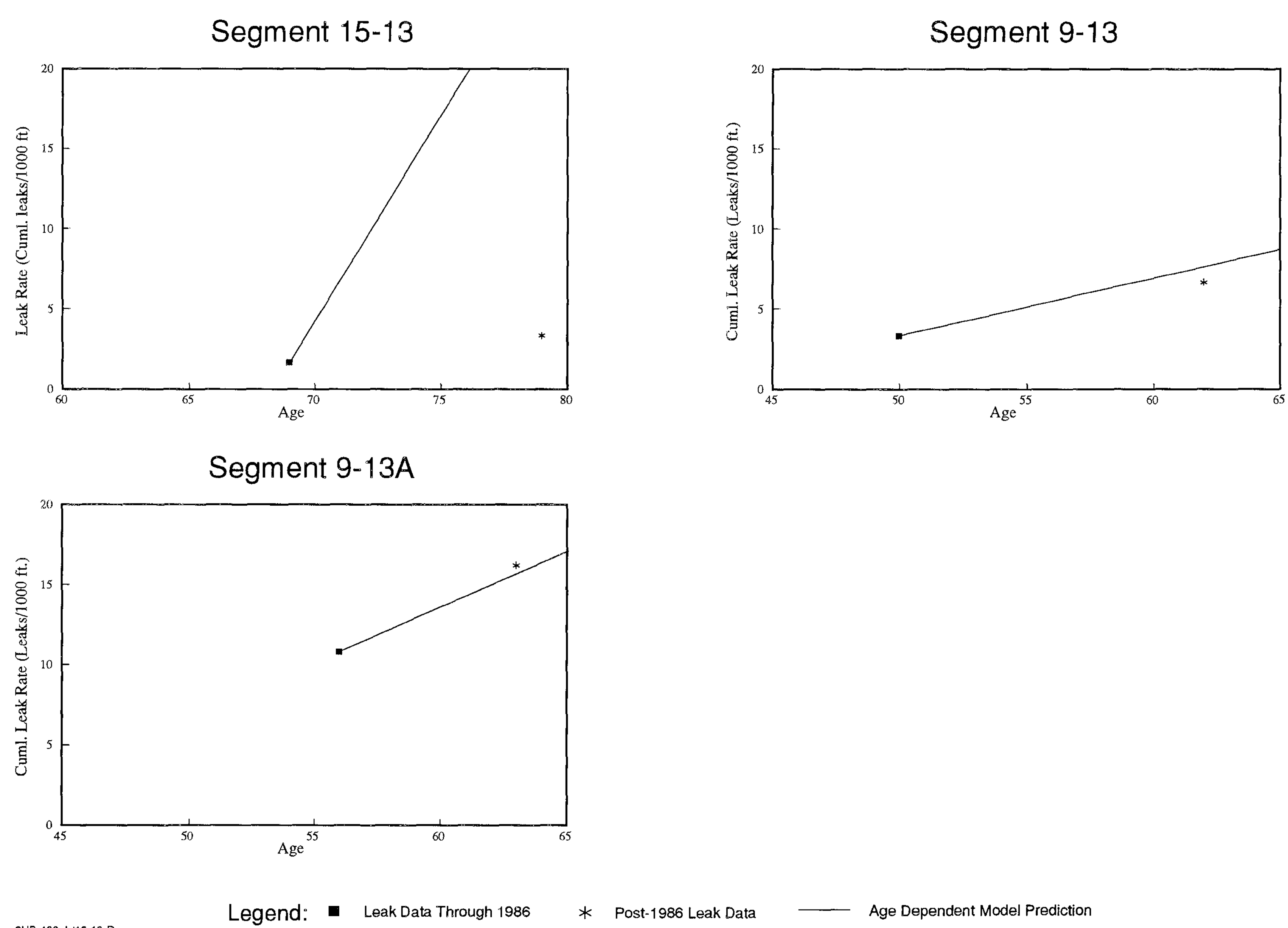

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Figure B-20: Comparison of Predicted Leak Rates from the Age Dependent Model to Actual Post-1986 Performance (Pipe Installed in 1927 with Limited Leakage)

B.5 CONCLUSIONS AND RECOMMENDATIONS

The assessment of pipeline data in the Torrance study area has led to the following conclusions:

1) The current method of leakage prediction is effective when sufficient leak data exists (i.e., at least three years with leakage)

2) Utilizing the leak history maps to represent historical leakage may underestimate leakage because the map updating procedure often obscures data, and reporting practices may have varied over time. Other sources of data are available, including the Leak Repair Order database, which includes every pipeline repair made sine 1970.

3) An alternative method (the age dependent model) for verifying linear regression predictions and/or estimating pipeline leakage based on limited leakage data can be developed.

In addition to the above conclusions, the following recommendations are made:

1) Since the pilot area used in this study was relatively small, a second analysis is recommended to confirm the trends developed in this first phase. This recommendation is considered significant only if the ability to predict future leaks based on limited data is considered important.

2) Two areas are suggested for further study. The first area should be similar, although larger in size, to the Torrance area analyzed in the first phase. The purpose of this assessment will be to confirm the trends observed in the pilot study. In general, the models developed would have the most applicability to these older areas. A second, newer area should be selected to determine if similar models can be developed for other parts of the service area.

3) The same type of analysis could be applied to other pipe classes. Although most corrosion problems appear to affect pre-1936 bare pipe without cathodic protection, there are a limited number of other pipe classes that are also affected by corrosion. One such candidate pipe class is poorly coated steel pipe, without cathodic protection, installed between 1941 and 1957.

B.6 REFERENCES

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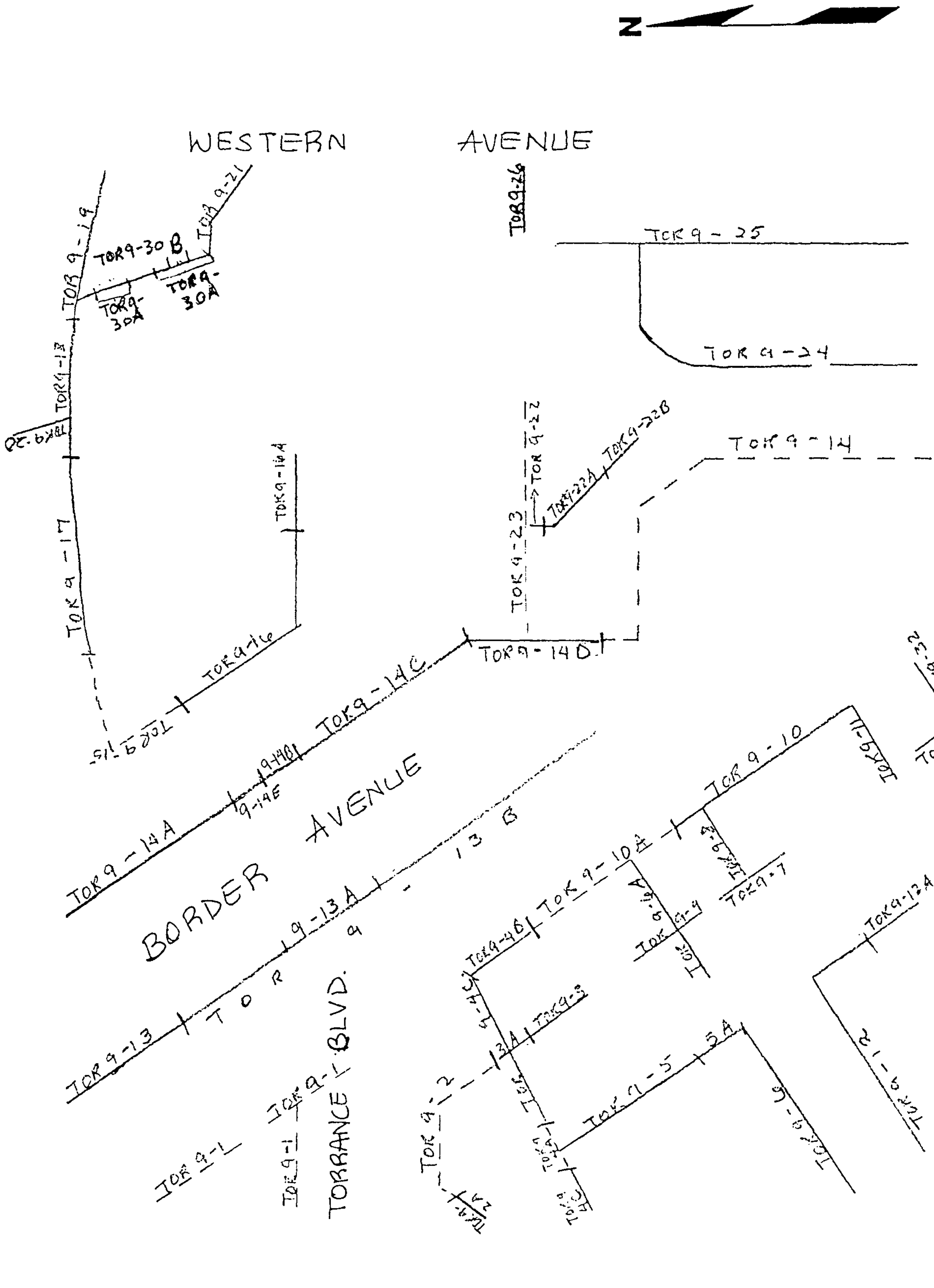
Strang, G.E. (1986), "Underground Piping System Replacement", Southern California Gas Company Engineering Department Report.

APPENDIX C

- INDEX MAPS TO ATLAS SHEETS

and

- PIPELINE SEGMENT DATABASE



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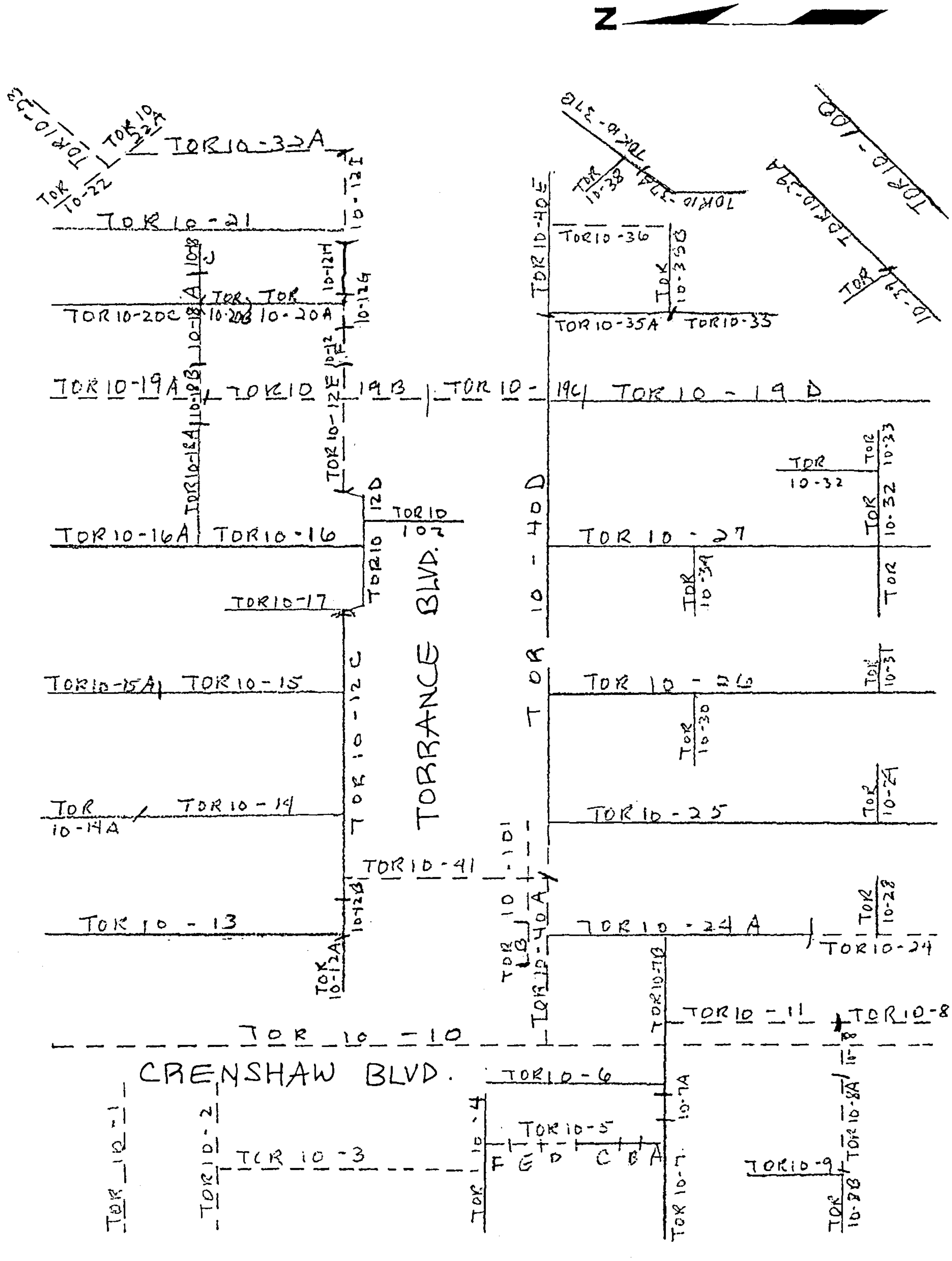
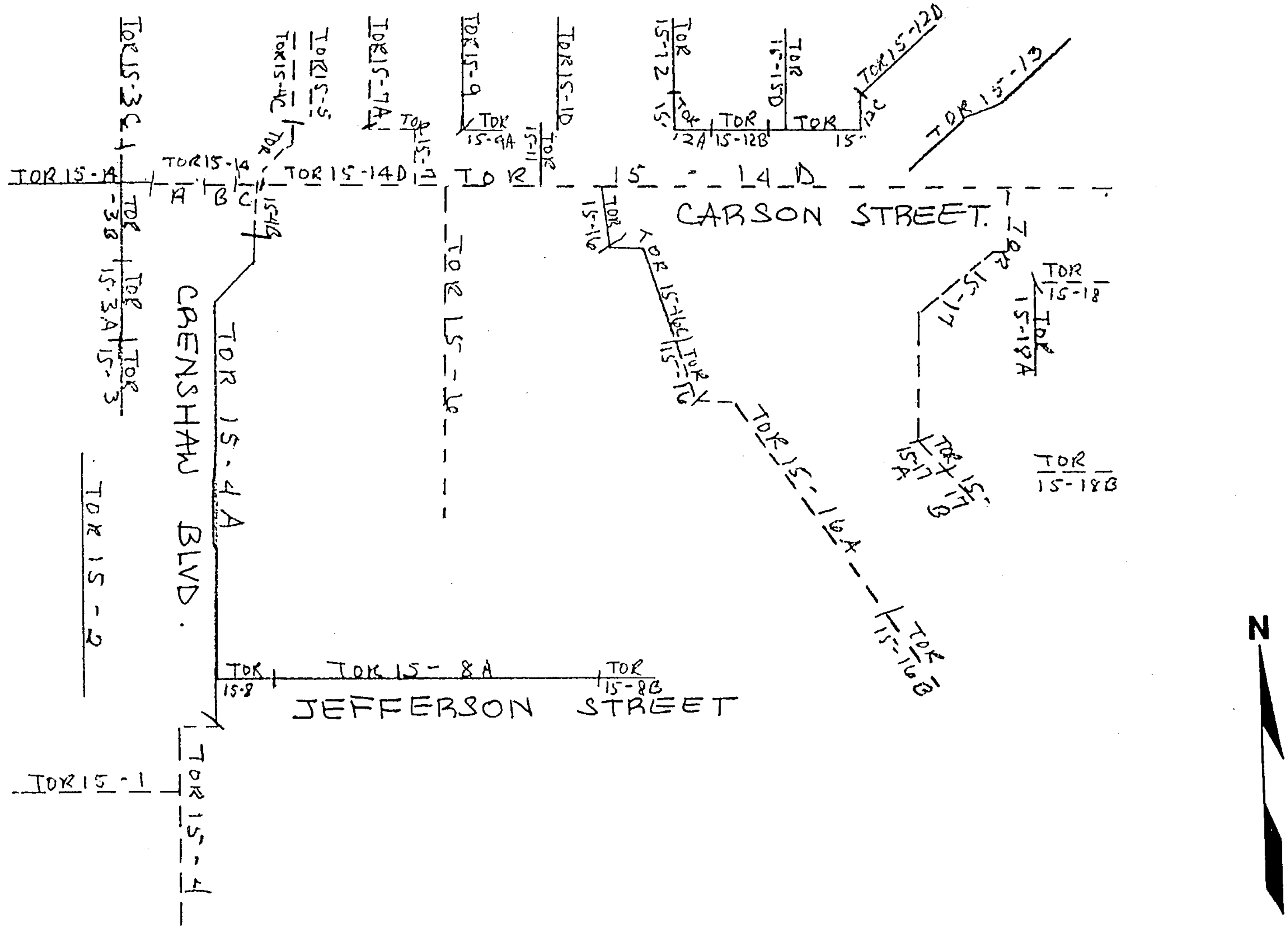
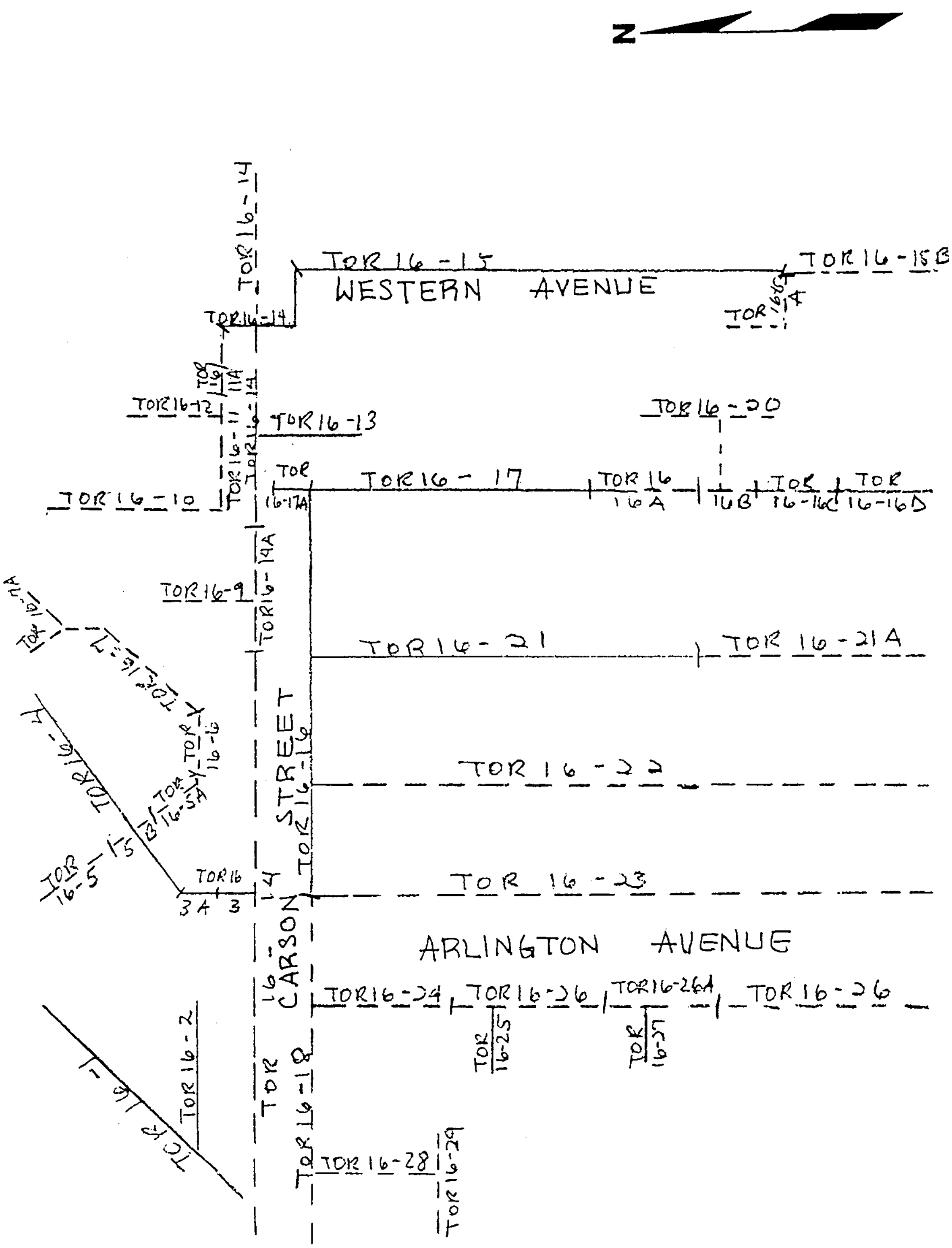


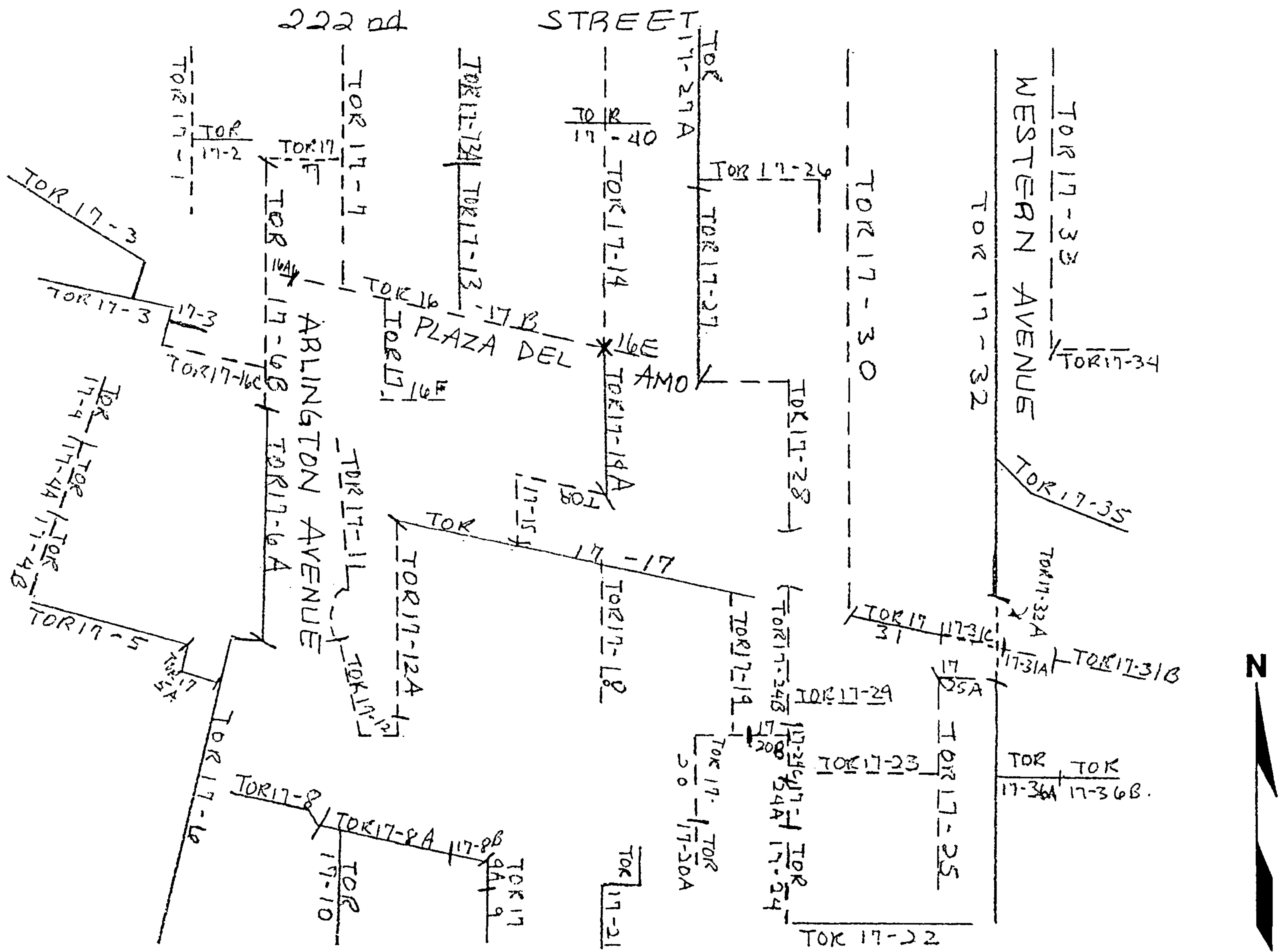
Schematic Index Map for Atlas Sheet Torrance 10



Schematic Index Map for Atlas Sheet Torrance 15



Schematic Index Map for Atlas Sheet Torrance 16



Schematic Index Map for Atlas Sheet Torrance 17

Seg #	Pipeline Segment#	<------- CURRENT PIPELINE INFORMATION ------->						<------- PREVIOUS PIPELINE INFORMATION ------>				
		Material	Diameter	Year Installed	Pressure	CP	Length in feet	Material	Diameter	Year Installed	Age at Repl.	CP
1	Tor 09-1	S	2	71	M	Y	825	S	2	13	58	N
2	Tor 09-2	S	3	56	M	Y	460					
3	Tor 09-2A	S	2	18	M	N	45					
4	Tor 09-3	S	2	13	M	N	125					
5	Tor 09-3A	P	3	85	M	N	50					
6	Tor 09-4A	S	3	76	M	Y	195	S	3	12	64	N
7	Tor 09-4B	P	2	85	M	N	250	S	3	12	73	N
8	Tor 09-4C	P	3	85	M	N	625	S	3	12	73	N
9	Tor 09-5	P	2	86	M	N	275	S	2	13	73	N
10	Tor 09-5A	P	2	86	M	N	75					
11	Tor 09-6	S	2	12	M	N	600					
12	Tor 09-6A	S	2	12	M	N	310					
13	Tor 09-7	S	1	66	M	N	100					
14	Tor 09-8	S	2	49	M	N	310					
15	Tor 09-9	S	2	54	M	N	200					
16	Tor 09-10	S	3	49	M	N	570					
17	Tor 09-10A	S	3	62	M	Y	400	S	3	12	50	N
18	Tor 09-11	S	3	70	M	N	350	S	3	12	58	N
19	Tor 09-12	P	2	86	M	N	335					
20	Tor 09-12A	S	2	73	M	Y	80					
21	Tor 09-13	P	2	90	M	N	300	S	2	27	63	N
22	Tor 09-13A	S	2	27	M	N	185					
23	Tor 09-13B	S	2	36	M	N	1200					
24	Tor 09-14	S	6	82	M	Y	855	S	6	13	69	N
25	Tor 09-14A	S	6	12	M	N	810					
26	Tor 09-14B	S	6	72	M	Y	26					
27	Tor 09-14C	S	6	13	M	N	400					
28	Tor 09-14D	S	6	73	M	N	350	S	6	25	48	N
29	Tor 09-14E	S	2	45	M	N	37					
30	Tor 09-15	S	2	73	M	Y	300	S	8	12	61	N
31	Tor 09-16	S	2	51	M	N	375					
32	Tor 09-16A	S	2	47	M	N	155					
33	Tor 09-17	P	2	87	M	N	475					
34	Tor 09-18	S	8	22	M	N	400					
35	Tor 09-19	S	4	12	M	N	120					
36	Tor 09-20	P	1	80	M	N	80					
37	Tor 09-21	S	8	60	M	N	285					
38	Tor 09-22	S	2	51	M	N	10					
39	Tor 09-22A	S	2	40	M	N	130					
40	Tor 09-22B	P	2	83	M	N	100					
41	Tor 09-23	S	3	51	M	Y	260					
42	Tor 09-24	P	3	89	M	N	1025					
43	Tor 09-25	P	3	89	M	N	900					
44	Tor 09-26	S	8	45	M	N	260					
45	Tor 09-30A	S	8	45	M	N	50					
46	Tor 09-30B	S	8	56	M	N	10					
47	Tor 09-31	S	3	13	M	N	90					
48	Tor 09-32	S	2	36	M	N	20					
49	Tor 10-1	S	2	51	M	Y	475					
50	Tor 10-2	S	2	51	M	Y	465					
51	Tor 10-3	S	2	51	M	Y	630					
52	Tor 10-4	S	2	35	M	N	460					
53	Tor 10-5A	S	2	27	M	N	75					
54	Tor 10-5B	S	2	35	M	N	85					
55	Tor 10-5C	S	2	37	M	N	100					
56	Tor 10-5D	S	2	39	M	Y	105					
57	Tor 10-5E	S	2	41	M	Y	125					
58	Tor 10-5F	S	2	56	M	Y	120					
59	Tor 10-6	P	2	83	M	N	500	S	3	24	59	N
60	Tor 10-7	S	2	27	M	N	330					
61	Tor 10-7A	S	2	26	M	N	190					
62	Tor 10-7B	P	2	83	M	N	275					
63	Tor 10-8	P	2	83	M	N	160	S	2	26	57	N

Seg #	Pipeline Segment#	Material	Diameter	Year Installed	Pressure	CP	Length in feet	Material	Diameter	Year Installed	Age at Repl.	CP
		<------- CURRENT PIPELINE INFORMATION ------->						<------- PREVIOUS PIPELINE INFORMATION ------>				
64	Tor 10-8A	S	2	51	M	Y	405					
65	Tor 10-8B	S	2	24	M	N	75					
66	Tor 10-9	P	2	85	M	N	250	S	2	24	61	N
67	Tor 10-10	S	8	83	H	Y	2205					
68	Tor 10-11	S	2	78	M	Y	540	S	2	24	54	N
69	Tor 10-12A	S	1	43	M	N	50					
70	Tor 10-12B	S	3	28	M	N	100					
71	Tor 10-12C	S	3	27	M	N	850					
72	Tor 10-12D	P	3	82	M	N	400	S	2	24	58	N
73	Tor 10-12E	S	3	74	M	Y	265					
74	Tor 10-12F	S	4	45	M	Y	45					
75	Tor 10-12G	S	3	56	M	Y	385					
76	Tor 10-12H	S	4	45	M	N	50					
77	Tor 10-12I	S	2	13	M	Y	500					
78	Tor 10-13	P	2	85	M	N	715	S	2	28	57	N
79	Tor 10-14	P	2	78	M	N	550	S	2	29	49	N
80	Tor 10-14A	S	2	39	M	N	185					
81	Tor 10-15*	S	2	27	M	N	395					
82	Tor 10-15A	S	2	29	M	N	355					
83	Tor 10-16	S	2	24	M	N	375					
84	Tor 10-16A	S	2	17	M	N	380					
85	Tor 10-17	S	2	25	M	N	320					
86	Tor 10-18A	S	2	17	M	N	860					
87	Tor 10-18B	S	2	74	M	Y	50					
88	Tor 10-18C	S	2	17	M	N	20					
89	Tor 10-19A	S	2	78	M	Y	375					
90	Tor 10-19B	S	2	74	M	Y	525	S	2	17	57	N
91	Tor 10-19C	S	4	56	M	Y	335					
92	Tor 10-19D	S	2	13	M	N	1010					
93	Tor 10-20A	S	2	17	M	N	325					
94	Tor 10-20B	NO RECORD										
95	Tor 10-20C	S	2	17	M	N	370					
96	Tor 10-21	P	2	78	M	N	740	S	2	16	62	N
97	Tor 10-22	S	2	75	M	Y	325					
98	Tor 10-22A	S	2	73	M	Y	270					
99	Tor 10-23	S	2	70	M	Y	290					
100	Tor 10-23A	S	2	73	M	Y	430					
101	Tor 10-24	S	2	72	M	Y	375					
102	Tor 10-24A	P	3	83	M	N	720	S	2	27	56	N
103	Tor 10-25	P	2	86	M	N	1125	S	2	27	59	N
104	Tor 10-26	P	2	86	M	N	1125	S	2	27	59	N
105	Tor 10-27	P	2	86	M	N	1110	S	2	27	59	N
106	Tor 10-28	P	2	85	M	N	70					
107	Tor 10-29	P	2	86	M	N	80					
108	Tor 10-30	P	2	86	M	N	110					
109	Tor 10-31	P	2	86	M	N	95					
110	Tor 10-32	P	2	86	M	N	280					
111	Tor 10-33	P	2	81	M	N	125					
112	Tor 10-34	P	2	86	M	N	120					
113	Tor 10-35	S	2	66	M	N	220					
114	Tor 10-35A	P	2	86	M	N	500	S	2	21	65	N
115	Tor 10-36	S	2	71	M	Y	495	S	2	22	49	N
116	Tor 10-37	S	2	38	M	N	120					
117	Tor 10-37A	S	2	19	M	N	200					
118	Tor 10-37B	S	2	18	M	N	135					
119	Tor 10-38	S	2	45	M	N	100					
120	Tor 10-39	P	2	78	M	N	204	S	3	37	41	N
121	Tor 10-39A	S	3	12	M	N	800					
122	Tor 10-40A	S	3	45	M	Y	465					
123	Tor 10-40D	P	2	86	M	N	1475	S	2	21	65	N
124	Tor 10-40E	P	2	78	M	N	360	S	2	22	56	N
125	Tor 10-41	S	4	39	M	Y	425					
126	Tor 10-100	S	2	12	M	N	185					

		<------- CURRENT PIPELINE INFORMATION				------->		<------- PREVIOUS PIPELINE INFORMATION			------>
Seg #	Pipeline Segment#	Material	Diameter	Year Installed	Pressure	CP	Length in feet	Material	Diameter	Year Installed	Age at Repl.	CP
127	Tor 10-101	S	4	39	M	Y	150					
128	Tor 10-101B	S	4	27	M	Y	15					
129	Tor 10-102	P	2	84	M	N	120	S	2	21	63	N
130	Tor 15-1	S	4	71	H	Y	500					
131	Tor 15-2	P	2	83	M	N	475					
132	Tor 15-3	S	2	39	M	N	210					
133	Tor 15-3A	S	2	27	M	N	310					
134	Tor 15-3B	P	2	91	M	N	185					
135	Tor 15-3C	S	2	51	M	Y	390					
136	Tor 15-4	S	8	79	H	Y	350	S	8	20	59	N
137	Tor 15-4A	S	8	45	H	N	1320					
138	Tor 15-4B	S	8	91	H	Y	225	S	8	24	67	N
139	Tor 15-4C	S	8	83	H	Y	340					
140	Tor 15-5	S	8	85	M	Y	290					
141	Tor 15-6	S	4	56	M	Y	905					
142	Tor 15-7	S	2	57	M	Y	325					
143	Tor 15-7A	S	2	78	M	Y	310					
144	Tor 15-8	S	4	45	M	N	24					
145	Tor 15-8A	S	4	27	H	N	1325					
146	Tor 15-8B	S	2	55	H	N	90					
147	Tor 15-9	P	2	86	M	N	275	S	2	27	59	N
148	Tor 15-9A	P	2	84	M	N	50					
149	Tor 15-10	P	2	86	M	N	260	S	2	27	59	N
150	Tor 15-11	S	1	73	M	Y	95					
151	Tor 15-12	S	2	27	M	N	225					
152	Tor 15-12A	S	2	41	M	N	165					
153	Tor 15-12B	S	3	24	M	N	250					
154	Tor 15-12C	S	3	12	M	N	275					
155	Tor 15-12D	P	2	84	M	N	320					
156	Tor 15-13	S	2	12	M	N	600					
157	Tor 15-14	P	4	91	M	N	240					
158	Tor 15-14A	S	4	51	M	Y	150					
159	Tor 15-14B	S	4	91	M	Y	35					
160	Tor 15-14C	S	4	73	M	Y	110					
161	Tor 15-14D	S	4	73	M	Y	2810					
162	Tor 15-15	S	2	24	M	N	150					
163	Tor 15-15B	S	2	13	M	N	300					
164	Tor 15-16	S	2	51	M	Y	236					
165	Tor 15-16A	S	3	55	M	Y	1010					
166	Tor 15-16B	S	3	56	M	Y	340					
167	Tor 15-16C	P	2	85	M	N	149					
168	Tor 15-17	S	2	69	M	Y	490					
169	Tor 15-17A	S	2	40	M	Y	95					
170	Tor 15-17B	S	2	46	M	Y	95					
171	Tor 15-18	S	2	74	M	Y	100					
172	Tor 15-18A	S	2	50	M	N	80					
173	Tor 15-18B	S	2	74	M	Y	50					
174	Tor 16-1	P	2	86	M	N	625	S	2	12	74	N
175	Tor 16-2	P	2	86	M	N	250					
176	Tor 16-3	S	3	50	M	N	40					
177	Tor 16-3A	S	3	59	M	N	55					
178	Tor 16-4	S	3	12	M	N	495					
179	Tor 16-4A	S	3	67	M	N	35					
180	Tor 16-5	S	2	50	M	Y	135					
181	Tor 16-5A	S	2	50	M	Y	235					
182	Tor 16-5B	S	2	67	M	Y	25					
183	Tor 16-6	S	2	48	M	Y	105					
184	Tor 16-7	S	2	54	M	Y	370					
185	Tor 16-7A	S	3	13	M	Y	50					
186	Tor 16-9	S	2	40	M	Y	160					
187	Tor 16-10	S	6	82	M	Y	435	S	6	13	69	N
188	Tor 16-11	S	6	41	M	Y	360					
189	Tor 16-11A	S	6	84	M	Y	25					

<------- CURRENT PIPELINE INFORMATION -------> <------- PREVIOUS PIPELINE INFORMATION ------>

Seg #	Pipeline Segment#	Material	Diameter	Year Installed	Pressure	CP	Length in feet	Material	Diameter	Year Installed	Age at Repl.	CP
190	Tor 16-12	S	6	41	M	Y	125					
191	Tor 16-13	P	2	86	M	N	275	S	4	18	68	N
192	Tor 16-14	S	6	73	M	Y	3010	S	4	12	61	N
193	Tor 16-14A	S	6	60	M	Y	300					
194	Tor 16-15	P	4	89	M	N	1380	S	4	13	76	N
195	Tor 16-15A	S	4	51	M	Y	130					
196	Tor 16-15B	S	6	70	M	Y	450					
197	Tor 16-16	S	3	12	M	N	920					
198	Tor 16-16A	S	2	70	M	Y	160					
199	Tor 16-16B	S	2	51	M	Y	75					
200	Tor 16-16C	S	2	77	M	Y	275	S	2	13	64	N
201	Tor 16-16D	S	2	13	M	N	210					
202	Tor 16-17	P	2	91	M	N	900	S	2	13	78	N
203	Tor 16-17A	P	2	91	M	N	60	S	2	57	34	N
204	Tor 16-18	S	2	74	M	Y	860	S	3	13	61	N
205	Tor 16-19	S	2	72	M	Y	160					
206	Tor 16-19A	S	2	91	M	Y	70					
207	Tor 16-20	S	2	72	M	Y	275					
208	Tor 16-21	P	2	80	M	N	1025	S	2	12	68	N
209	Tor 16-21A	S	4	58	M	Y	610					
210	Tor 16-22	S	2	68	M	Y	1635					
211	Tor 16-23	S	4	50	M	Y	1635					
212	Tor 16-24	S	2	69	M	Y	500					
213	Tor 16-25	P	2	86	M	N	85					
214	Tor 16-26	S	2	69	M	Y	880					
215	Tor 16-26A	S	2	58	M	Y	295					
216	Tor 16-27	S	2	48	M	Y	160					
217	Tor 16-28	S	2	74	M	Y	275	S	2	13	61	N
218	Tor 16-29	S	2	74	M	Y	125					
219	Tor 17-1	S	2	68	M	Y	240					
220	Tor 17-2	P	2	86	M	N	75					
221	Tor 17-3	P	2	79	M	N	700					
222	Tor 17-4	S	2	50	M	Y	60					
223	Tor 17-4A	S	2	50	M	Y	170					
224	Tor 17-4B	S	2	48	M	Y	135					
225	Tor 17-5	P	2	79	M	N	300	S	2	23	56	N
226	Tor 17-5A	P	2	81	M	N	65	S	2	23	58	N
227	Tor 17-6	P	4	81	M	N	920	S	4	22	59	N
228	Tor 17-6A	S	4	22	M	N	570					
229	Tor 17-6B	S	4	79	M	Y	530	S	4	26	53	N
230	Tor 17-6C	S	2	79	M	Y	330					
231	Tor 17-7	S	4	50	M	Y	550					
232	Tor 17-8	S	2	47	M	N	120					
233	Tor 17-8B	S	3	30	M	N	220					
233	Tor 17-8A	S	3	34	M	N	250					
234	Tor 17-9	S	4	23	M	N	360					
235	Tor 17-9A	S	4	30	M	N	35					
236	Tor 17-10	P	2	84	M	N	485	S	2	47	37	N
237	Tor 17-11	S	1	43	M	Y	450					
238	Tor 17-12	S	2	48	M	Y	250					
239	Tor 17-12A	S	2	41	M	Y	430					
240	Tor 17-13	S	2	13	M	N	300					
241	Tor 17-13A	S	2	59	M	Y	185					
242	Tor 17-14	S	4	58	M	Y	600					
243	Tor 17-14A	S	2	16	M	N	260					
244	Tor 17-15	S	2	65	M	Y	325					
245	Tor 17-16A	S	3	79	M	Y	15					
246	Tor 17-16B	S	3	69	M	Y	845					
247	Tor 17-16E	S	1	70	M	Y	100					
248	Tor 17-16F	P	2	87	M	N	225					
249	Tor 17-17	P	2	78	M	N	900	S	2	16	62	N
250	Tor 17-18	S	2	41	M	Y	415					
251	Tor 17-19	S	2	42	M	Y	465					

Seg #	Pipeline Segment#	Material	Diameter	Year Installed	Pressure	CP	Length in feet	Material	Diameter	Year Installed	Age at Repl.	CP
	<------- CURRENT PIPELINE INFORMATION ------->							<------- PREVIOUS PIPELINE INFORMATION ------>				
252	Tor 17-20	S	2	48	M	Y	540					
253	Tor 17-20A	S	2	52	M	Y	120					
254	Tor 17-20B	S	2	49	M	Y	100					
255	Tor 17-21	P	2	82	M	N	240					
256	Tor 17-22	P	2	85	M	N	1200					
257	Tor 17-23	S	3	49	M	Y	1200					
258	Tor 17-24	S	2	50	M	Y	350					
259	Tor 17-24A	S	3	49	M	Y	170					
260	Tor 17-24B	S	3	56	M	Y	350					
261	Tor 17-25	S	3	49	M	Y	250					
262	Tor 17-25A	S	2	62	M	Y	120					
263	Tor 17-26	S	2	72	M	Y	260					
264	Tor 17-27*	P	2	88	M	N	590	S	2	13	75	N
265	Tor 17-27A	S	2	65	M	N	50					
266	Tor 17-27B	S	2	13	M	N	70					
267	Tor 17-28	S	1	65	M	Y	325					
268	Tor 17-29	S	2	56	M	Y	635					
269	Tor 17-30	S	6	70	M	Y	1165					
270	Tor 17-31	S	4	23	M	N	775					
271	Tor 17-31A	S	2	49	M	Y	75					
272	Tor 17-31B	S	2	47	M	Y	70					
273	Tor 17-31C	S	4	81	M	Y	30	S	4	49	32	N
274	Tor 17-32	S	8	49	M	N	2180					
275	Tor 17-32A	S	8	81	M	Y	150					
276	Tor 17-33	S	4	59	M	Y	710					
277	Tor 17-34	S	3	59	M	Y	70					
278	Tor 17-35	S	2	52	M	N	165					
279	Tor 17-36A	S	2	49	M	N	90					
280	Tor 17-36B	S	2	47	M	N	50					
281	Tor 17-40	S	2	22	M	N	190					

							106241					

APPENDIX D

LEAK DATABASE

MAIN REPAIR LEAKS - MODIFIED LEAK REPAIR ORDER DATABASE

Leak Order Number	ATLAS SHEET	LEAK PRIO	Address or Location	SIZE	DIAMETER (inches)	Facility	LEAK In	Cause	Repair Type	Material	Year Installed	Detect Date	Action Date	Pipeline Segment Number	Pipeline info (C=CURRENT P=PREVIOUS)
76 -683118	TOR0009	2	ALLEY W/O CRAVENS	200	2	1	1	1	1	4	1913	03/01/1976	03/01/1976	TOR09-001	C
88 - 60020	TOR0009	1	1318 CRAVENS	200	2	1	1	1	1	4	1971	08/18/1988	08/18/1988	TOR09-003	P
78 -929595	TOR0009	2	2014 TORRANCE BLVD	300	3	1	1	1	1	4	1912	01/01/1978	01/01/1978	TOR09-004B	P
79 - 51170	TOR0009	3	1313 POST AVE	300	3	1	1	1	1	4	1912	01/01/1979	01/01/1979	TOR09-004B	P
80 - 2246	TOR0009	3	2014 TORRANCE BLVD	300	3	1	1	1	1	4	1956	09/11/1980	04/11/1981	TOR09-004C	P
85 - 36725	TOR0009	2	1411 POST AV	200	2	1	1	1	1	4	1930	08/14/1985	05/14/1985	TOR09-005	P
87 - 12424	TOR0009	1	1444 POST AVE	200	2	1	1	1	1	4	1922	08/21/1987	08/21/1987	TOR09-006	C
92 - 82157	TOR0009	3	1417 EL PRADO AV	200	2	1	1	1	1	4	1900	08/06/1992	08/06/1992	TOR09-006	C
82 - 27790	TOR0009	2	1269 SARTORI	200	2	1	1	1	1	4	1912	09/14/1982	09/14/1982	TOR09-006A	C
92 - 82235	TOR0009	3	1265 SARTORI	200	2	1	1	1	1	4	1912	08/12/1992	08/17/1992	TOR09-006A	C
77 -818772	TOR0009	3	ALLEY E/O CRAVENS & S/O POST	200	2	1	1	1	1	4	1912	01/01/1977	01/01/1977	TOR09-006A	C
75 -744457	TOR0009	1	1414 CEAVENS	200	2	1	1	1	1	4	1912	03/01/1975	03/01/1975	TOR09-006A	C
80 - 2070	TOR0009	2	1414 CRAVENS	200	2	1	1	1	1	4	1950	10/22/1980	10/22/1980	TOR09-009	C
89 - 60031	TOR0009	1	923 VAN NESS	200	2	1	1	1	1	4	1927	08/22/1989	08/22/1989	TOR09-013	P
77 -844488	TOR0009	3	921 VAN NESS	200	2	1	1	1	1	2	1972	12/01/1977	12/01/1977	TOR09-013	P
83 - 30134	TOR0009	3	1971 TORRANCE BLVD	200	2	1	1	1	1	4	1926	07/21/1983	07/21/1983	TOR09-013A	C
80 -09578B	TOR0009	3	925 VAN NESS	200	2	1	1	1	1	4	1936	12/18/1980	07/18/1981	TOR09-013B	C
80 -09578A	TOR0009	1	925 VAN NESS	200	2	1	1	1	1	4	1936	12/18/1980	12/18/1980	TOR09-013B	C
84 - 51241	TOR0009	1	923 VAN NESS AVE	200	2	1	1	1	1	4	1939	03/07/1984	03/07/1984	TOR09-013B	C
84 - 38639	TOR0009	1	923 VAN NESS AVE	200	2	1	1	1	1	4	1939	03/07/1984	03/07/1984	TOR09-013B	C
77 -876992	TOR0016	3	1500 CABRILLO	600	6	1	1	1	1	4	1913	08/01/1977	08/01/1977	TOR09-014	P
81 - 11919	TOR0009	3	1502 CABRILLO AVE	600	6	1	1	1	1	4	1925	09/28/1981	02/28/1982	TOR09-014	P
79 -994782	TOR0009	1	908 VAN NESS	600	6	1	1	1	1	4	1912	07/01/1979	07/01/1979	TOR09-014A	C
89 - 40448	TOR0009	3	N/E COR VAN NESS & MULLEN AV	600	6	1	1	1	1	4	1912	08/22/1989	08/22/1990	TOR09-014A	C
89 - 40451	TOR0009	3	1820 TORRANCE BL	200	2	1	1	1	1	2	1947	08/24/1989	08/24/1990	TOR09-016A	C
76 -683120	TOR0009	1	1820 TORRANCE BLVD.	200	2	1	1	1	1	2	1947	02/01/1976	02/01/1976	TOR09-016A	C
86 - 90074	TOR0009	3	N/W I/S 213TH ST & BOW	300	3	1	1	1	4	2	1951	03/21/1986	03/21/1987	TOR09-023	C
84 - 56813	TOR0009	3	N/W CORNER WESTERN & 213TH ST	800	8	1	1	1	1	2	1945	03/12/1984	02/12/1985	TOR09-026	C
91 - 15032	TOR0009	1	NW 213 & WESTERN	800	8	1	1	1	1	2	1945	08/19/1991	08/19/1991	TOR09-026	C
86 - 26051	TOR0010	2	2512 TORRANCE BL	200	2	1	1	1	1	2	1935	01/06/1986	01/06/1986	TOR10-004	C
82 - 21994	TOR0010	3	2558 TORRANCE BLVD	200	2	1	1	1	1	2	1935	06/11/1982	04/11/1983	TOR10-004	C
84 - 51787	TOR0010	3	1324 DATE AVE	200	2	1	1	1	1	2	1927	08/28/1984	08/28/1984	TOR10-005A	C
85 - 36251	TOR0010	2	1326 DATE	200	2	1	1	1	1	4	1927	05/31/1985	06/14/1985	TOR10-005A	C
88 - 20573	TOR0010	3	2515 EL DORADO ST	200	2	1	1	1	1	4	1926	12/01/1988	02/01/1989	TOR10-007A	C
75 -686462	TOR0010	3	1606 CRENSHAW BLVD	200	2	1	1	1	1	4	1926	02/01/1975	02/01/1975	TOR10-008	P
84 - 39655	TOR0010	2	2555 SONOMA	200	2	1	1	1	1	3	1951	11/26/1984	11/26/1984	TOR10-008A	C
84 - 39583	TOR0010	2	2555 SONOMA	200	2	1	1	1	1	3	1951	11/14/1984	11/14/1984	TOR10-008A	C
82 - 22002	TOR0010	3	1512 DATE AVE	200	2	1	1	1	1	4	1924	06/11/1982	04/11/1983	TOR10-009	P
78 -936778	TOR0010	3	2555 SONOMA	200	2	1	1	1	1	4	1927	07/01/1978	07/01/1978	TOR10-009	P
84 - 51799	TOR0010	3	1508 DATE AV	200	2	1	1	1	1	2	1924	08/30/1984	08/30/1984	TOR10-009	P
88 - 20569	TOR0010	3	2371 TORRANCE BLVD	300	3	1	1	1	1	4	1927	12/01/1988	08/01/1989	TOR10-012C	C
84 - 31444	TOR0010	1	1027 ACACIA	300	3	1	1	1	1	4	1927	11/15/1984	11/15/1984	TOR10-012C	C
86 - 60325	TOR0010	3	2413 TORRANCE BLVD	300	3	1	1	1	1	4	1927	11/26/1986	10/26/1987	TOR10-012C	C
82 - 28741	TOR0010	3	1104 AMAPOLA	200	2	1	1	1	1	4	1924	06/09/1982	06/09/1982	TOR10-012D	P
78 -976417	TOR0010	1	2313 TORR BLVD	200	2	1	1	1	1	4	1926	06/01/1978	06/01/1978	TOR10-012D	P
78 -933750	TOR0010	2	2305 TORR BL.	200	2	1	1	1	1	4	1924	07/01/1978	07/01/1978	TOR10-012D	P
78 -976416	TOR0010	1	2305 TORR BLVD.	200	2	1	1	1	1	4	1926	07/01/1978	07/01/1978	TOR10-012D	P
78 -976419	TOR0010	1	2306-2308 TORR BLVD	200	2	1	1	1	1	4	1921	06/01/1978	06/01/1978	TOR10-012D	P
78 -933831	TOR0010	1	1103 PORTOLA AVE	300	3	1	1	1	1	2	1956	06/01/1978	06/01/1978	TOR10-012G	C
84 - 7092	TOR0010	3	1019 BEECH	200	2	1	1	1	1	4	1928	11/15/1984	12/15/1984	TOR10-013	P

MAIN REPAIR LEAKS - MODIFIED LEAK REPAIR ORDER DATABASE

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78 -990162	TOR0010	1	811-815 BEECH AVE.	200	2	1	1	1	1	4	1928	06/01/1978	06/01/1978	TOR10-013	P
85 - 36295	TOR0010	2	815 BEECH	200	2	1	1	1	1	4	1928	06/10/1985	06/10/1985	TOR10-013	P
78 -990160	TOR0010	1	917 BEECH AVE	200	2	1	1	1	1	4	1928	06/01/1978	06/01/1978	TOR10-013	P
82 - 28689	TOR0010	1	812 CRENSHAW BLVD	200	2	1	1	1	1	4	1928	06/01/1982	06/01/1982	TOR10-013	P
82 - 28685	TOR0010	1	811 BEECH AVE	200	2	1	1	1	1	4	1928	05/28/1982	05/28/1982	TOR10-013	P
84 - 31385	TOR0010	3	1020 CRENSHAW BLVD	200	2	1	1	1	1	2	1928	10/26/1984	10/26/1984	TOR10-013	P
78 - 25266	TOR0010	3	1007 BEECH AVE	200	2	1	1	1	1	4	1928	10/01/1978	10/01/1978	TOR10-013	P
78 -990179	TOR0010	1	1015-1023 ACACIA	200	2	1	1	1	1	4	1929	06/01/1978	06/01/1978	TOR10-014	P
82 - 21995	TOR0010	3	O ACACIA AVE	200	2	1	1	1	1	4	1927	06/11/1982	04/11/1983	TOR10-015	P
82 - 28711	TOR0010	1	1103 AMAPOLA AVE	200	2	1	1	1	1	4	1924	06/03/1982	06/03/1982	TOR10-016	C
78 - 25273	TOR0010	3	2310 SIERRA ST	200	2	1	1	1	1	4	1924	10/01/1978	10/01/1978	TOR10-016	C
82 - 28778	TOR0010	1	1103 AMAPOLA	200	2	1	1	1	1	4	1925	06/17/1982	06/17/1982	TOR10-016	C
84 - 7389	TOR0010	3	1006 SIERRA PL	200	2	1	1	1	1	4	*1925	12/05/1984	10/05/1985	TOR10-017	C
84 - 7390	TOR0010	2	1012 SIERRA PL	200	2	1	1	1	1	4	1925	12/05/1984	12/19/1984	TOR10-017	C
90 - 9683	TOR0010	1	918 S COTA AV	200	2	1	1	1	2	4	1900	03/05/1990	03/05/1990	TOR10-018A	C
90 - 2618	TOR0010	3	I/S SIERRA & PORTOLA AV	200	2	1	1	1	1	4	1917	10/31/1990	07/31/1991	TOR10-018A	C
77 -866151	TOR0010	3	I/S COTA & SIERRA ST	200	2	1	1	1	1	4	1917	01/01/1977	01/01/1977	TOR10-018A	C
78 -933640	TOR0010	2	917-19 PORTOLA	200	2	1	1	1	1	4	1917	07/01/1978	07/01/1978	TOR10-018A	C
88 - 20570	TOR0010	3	SONOMA & ALLEY W/COTA	200	2	1	1	1	1	4	1913	12/01/1988	08/01/1989	TOR10-019D	C
88 - 20572	TOR0010	3	S/E COR ELDORADO & ALLEY W/O COTA	200	2	1	1	1	1	4	1913	12/01/1988	08/01/1989	TOR10-019D	C
86 - 37759	TOR0010	1	1417 COTA AVE	200	2	1	1	1	1	4	1913	01/06/1986	01/06/1986	TOR10-019D	C
87 - 40318	TOR0010	1	1507 COTA AVE	200	2	1	1	1	1	4	1913	01/26/1987	01/26/1987	TOR10-019D	C
87 - 8427	TOR0010	3	1421 COTA AVE	200	2	1	1	1	1	4	1913	01/27/1987	01/27/1988	TOR10-019D	C
83 - 50134	TOR0010	2	1411 COTA AVE	200	2	1	1	1	1	4	1913	02/14/1983	02/14/1983	TOR10-019D	C
82 - 28749	TOR0010	2	1417 COTA AVE	200	2	1	1	1	1	4	1913	06/09/1982	06/09/1982	TOR10-019D	C
82 - 22001	TOR0010	3	INT ALLEY W/O COTA & N/PL ELDOR	200	2	1	1	1	1	2	1913	06/11/1982	06/11/1983	TOR10-019D	C
86 - 3426	TOR0010	3	1421 COTA AVE	200	2	1	1	1	1	3	1966	03/21/1986	03/21/1987	TOR10-019D	C
83 - 29995	TOR0010	3	1225 COTA	200	2	1	1	1	1	4	1921	05/27/1983	05/27/1983	TOR10-019D	C
85 - 36942	TOR0010	3	1403 COTA	200	2	1	1	1	1	4	1913	09/18/1985	09/18/1985	TOR10-019D	C
83 - 50141	TOR0010	2	1418 AMAPOLA AVE	200	2	1	4	1	1	4	1913	02/15/1983	02/15/1983	TOR10-019D	C
78 -933832	TOR0010	2	1103 PORTOLA AVE	200	2	1	1	1	1	4	1917	06/01/1978	06/01/1978	TOR10-020A	C
84 - 39710	TOR0010	3	1103 PORTOLA AVE	200	2	1	1	1	1	4	1917	12/03/1984	12/03/1984	TOR10-020A	C
78 -909637	TOR0010	3	1103 PORTOLA AV	200	2	1	1	1	1	4	1978	09/01/1978	09/01/1978	TOR10-020A	C
78 -976413	TOR0010	1	1007-1011 ARLINGTON	200	2	1	1	1	1	4	1916	06/01/1978	06/01/1978	TOR10-021	P
78 -976424	TOR0010	1	921 ARLINGTON	200	2	1	1	1	1	4	1916	06/01/1978	06/01/1978	TOR10-021	P
78 -818735	TOR0010	2	824 PORTOLA ALLEY E/O	200	2	1	5	1	1	4	1919	06/01/1978	06/01/1978	TOR10-021	P
82 - 21717	TOR0010	3	1303 BEACH AVE	200	2	1	1	1	1	4	1927	06/16/1982	09/16/1982	TOR10-024A	P
82 - 27456	TOR0010	3	1303 BEECH AVE	200	2	1	1	1	1	4	1927	06/15/1982	06/15/1982	TOR10-024A	P
82 - 50012	TOR0010	2	1230 CRENSHAW BLVD	200	2	1	1	1	1	4	1927	12/17/1982	12/17/1982	TOR10-024A	P
82 - 28774	TOR0010	3	1303 BEECH AVE	200	2	1	1	1	1	4	1927	06/16/1982	06/16/1982	TOR10-024A	P
78 -933839	TOR0010	2	6217 ACACIA AVE	200	2	1	1	1	1	4	1917	06/01/1978	06/01/1978	TOR10-025	P
78 - 25269	TOR0010	3	2414 SONDMA AVE	200	2	1	1	1	1	4	1927	10/01/1978	10/01/1978	TOR10-025	P
78 -990166	TOR0010	1	1217-1221 ACACIA AVE	200	2	1	1	1	1	4	1927	06/01/1978	06/01/1978	TOR10-025	P
79 -102951	TOR0010	1	ALLEY W/O ACACIA N/O SONOMA	200	2	1	1	1	1	4	1927	10/01/1979	10/01/1979	TOR10-025	P
78 - 25276	TOR0010	3	SE COR SONOMA & ALY W/ACACIA	200	2	1	1	1	1	4	1927	09/01/1978	09/01/1978	TOR10-025	P
77 -915778	TOR0010	3	2414 SONOMA AVE	200	2	1	1	1	1	4	1925	07/01/1977	07/01/1977	TOR10-025	P
81 - 11324	TOR0010	3	1423 ACACIA AVE	200	2	1	1	1	1	4	1927	05/14/1981	07/14/1981	TOR10-025	P
78 -990168	TOR0010	1	2415 SONOMA AVE	200	2	1	1	1	2	4	1927	06/01/1978	06/01/1978	TOR10-025	P
84 - 39666	TOR0010	1	1503 MADRID	200	2	1	1	1	1	4	1927	11/27/1984	11/27/1984	TOR10-026	P
84 - 51840	TOR0010	3	1503 MADRID AVE	200	2	1	1	1	1	2	1927	09/11/1984	09/11/1984	TOR10-026	P

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79 - 51442	TOR0010	3	1313 AMAPOLA AVE	200	2	1	1	1	1	4	1923	02/01/1979	02/01/1979	TOR10-027	P
78 - 25265	TOR0010	3	1303 AMAPOLA	200	2	1	1	1	1	4	1921	10/01/1978	10/01/1978	TOR10-027	P
82 - 28757	TOR0010	1	1217 AMAPOLA AVE	200	2	1	1	1	1	4	1921	06/11/1982	06/11/1982	TOR10-027	P
84 - 31233	TOR0010	3	1229 PORTOLA	200	2	1	1	1	1	4	1921	09/06/1984	09/06/1984	TOR10-035A	P
82 - 27434	TOR0010	1	1303 PORTOLA AVE	200	2	1	1	1	1	4	1921	06/10/1982	06/10/1982	TOR10-035A	P
82 - 27433	TOR0010	1	1215 PORTOLA AVE	200	2	1	1	1	1	4	1921	06/10/1982	06/10/1982	TOR10-035A	P
84 - 39705	TOR0010	1	1217 PORTOLA	200	2	1	1	1	1	4	1921	12/03/1984	12/03/1984	TOR10-035A	P
82 - 28759	TOR0010	3	1229 PORTOLA AVE	200	2	1	1	1	1	4	1921	06/11/1982	06/11/1982	TOR10-035A	P
84 - 39659	TOR0010	1	1217 PORTOLA	200	2	1	1	1	1	4	1920	11/27/1984	11/27/1984	TOR10-035A	P
78 -990154	TOR0010	1	1307 PORTOLA AVE	200	2	1	1	1	1	4	1921	06/01/1978	06/01/1978	TOR10-035A	P
83 - 50544	TOR0010	3	ALLEY W/O PORTOLA & ELDORADO AVE	200	2	1	1	1	1	4	1971	07/01/1983	07/01/1983	TOR10-036	C
84 - 39653	TOR0010	1	1228 ARLINGTON AVE	200	2	1	1	1	1	4	1938	11/26/1984	11/26/1984	TOR10-037	C
83 - 22414	TOR0009	3	ALLEY N/O ENGRACIA S/O TORRANCE	200	2	1	1	1	1	4	1918	02/15/1983	02/15/1984	TOR10-037B	C
76 -683487	TOR0010	3	1527 POST AVE	300	3	1	1	1	1	4	1924	08/01/1976	08/01/1976	TOR10-039A	C
90 - 2620	TOR0010	3	1412 ENGARCIA AV	300	3	1	1	1	1	4	1917	10/31/1990	06/30/1991	TOR10-039A	C
92 - 82276	TOR0010	3	1442 S ENGRACIA AV	300	3	1	1	1	1	4	1900	08/17/1992	08/17/1992	TOR10-039A	C
88 - 20031	TOR0010	3	1404 ENGRACIA AVE	300	3	1	1	1	1	4	1912	02/04/1988	05/04/1988	TOR10-039A	C
78 - 26537	TOR0010	3	1412 ENGRACIA AVE	300	3	1	1	1	1	4	1912	12/01/1978	12/01/1978	TOR10-039A	C
84 - 39628	TOR0010	1	2368 TORRANCE BL	200	2	1	1	1	1	4	1921	11/20/1984	11/20/1984	TOR10-040D	P
84 - 39629	TOR0010	1	2206 TORRANCE BL	200	2	1	1	1	1	4	1921	11/20/1984	11/20/1984	TOR10-040D	P
84 - 39636	TOR0010	1	2224 TORRANCE BL	200	2	1	1	1	1	4	1935	11/21/1984	11/21/1984	TOR10-040D	P
84 - 39652	TOR0010	2	2304 TORRANCE BLVD	200	2	1	1	1	1	4	1928	11/23/1984	11/23/1984	TOR10-040D	P
84 - 39664	TOR0010	1	2304 TORR BLVD	200	2	1	1	1	1	4	1928	11/27/1984	11/27/1984	TOR10-040D	P
84 - 39651	TOR0010	1	2308 TORR	200	2	1	1	1	1	4	1928	11/23/1984	11/23/1984	TOR10-040D	P
84 - 39635	TOR0010	1	2212 TORRANCE BLVD	200	2	1	1	1	1	4	1921	11/21/1984	11/21/1984	TOR10-040D	P
78 -976418	TOR0010	1	1213 COTA AVE	200	2	1	1	1	1	4	1921	06/01/1978	06/01/1978	TOR10-040D	P
84 - 39776	TOR0010	3	2306 TORRANCE BLVD	200	2	1	1	1	1	2	1917	12/12/1984	12/12/1984	TOR10-040D	P
84 - 39631	TOR0010	1	2260 TORRANCE BL	200	2	1	1	1	1	4	1935	11/20/1984	11/20/1984	TOR10-040D	P
78 - 25275	TOR0010	3	2166 TORRANCE BLVD	200	2	1	1	1	1	4	1922	10/01/1978	10/01/1978	TOR10-040E	P
75 -719454	TOR0010	3	2208 TORRANCE BLVD.	200	2	1	1	1	1	4	1922	08/01/1975	08/01/1975	TOR10-040E	P
78 -909566	TOR0010	1	2172 TORR BL.	200	2	1	6	1	5	4	1922	04/01/1978	04/01/1978	TOR10-040E	P
78 -976079	TOR0010	1	2166 TORR BLVD	200	2	1	1	1	1	4	1922	10/01/1978	10/01/1978	TOR10-040E	P
78 - 25274	TOR0010	3	2154 TORRANCE BLVD	200	2	1	1	1	1	4	1922	10/01/1978	10/01/1978	TOR10-040E	P
75 -685902	TOR0010	3	2208 TORRANCE BLVD	200	2	1	1	1	1	4	1922	08/01/1975	08/01/1975	TOR10-040E	P
78 -915722	TOR0010	1	2172 TORR BL	200	2	1	1	1	1	4	1922	04/01/1978	04/01/1978	TOR10-040E	P
78 -990155	TOR0010	1	2214 TORR BLVD	200	2	1	1	1	1	4	1921	06/01/1978	06/01/1978	TOR10-040E	P
84 - 7450	TOR0010	1	ON TORRANCE BL 12' W/W AMAPOLA	200	2	1	1	1	1	4	1921	09/11/1984	09/11/1984	TOR10-102	P
84 - 7454	TOR0010	1	ON TORRANCE BLVD 64 W/O AMAPOLA	200	2	1	1	1	1	4	1921	09/11/1984	09/11/1984	TOR10-102	P
89 - 60021	TOR0015	2	1724 DATE X CARSON	200	2	1	1	1	1	4	1927	08/17/1989	08/17/1989	TOR15-003A	C
77 -844465	TOR0015	1	1726 DATE AVE	200	2	1	1	1	1	4	1927	08/01/1977	08/01/1977	TOR15-003A	C
78 -909584	TOR0015	1	CRENSHAW BL. & TOLEDO ST.	800	8	1	1	1	1	4	1920	05/01/1978	05/01/1978	TOR15-004	P
89 - 40349	TOR0015	3	N/E CRN JEFFERSON/CRENSHAW	800	8	1	1	1	1	4	1945	08/15/1989	08/15/1990	TOR15-004A	C
81 - 18634	TOR0015	1	2341 JEFFERSON	400	4	1	1	1	1	4	1920	06/12/1981	06/12/1981	TOR15-008A	C
75 -719033	TOR0015	1	OAK ST & JEFFERSON	400	4	1	1	1	1	4	1927	01/01/1975	01/01/1975	TOR15-008A	C
85 - 35613	TOR0015	1	234 1JEFFERSON	400	4	1	1	1	1	2	1927	03/18/1985	03/18/1985	TOR15-008A	C
77 -915774	TOR0015	1	N/E COR OAK & JEFFERSON ST	400	4	1	1	1	1	4	1927	07/01/1977	07/01/1977	TOR15-008A	C
86 - 38784	TOR0015	2	2341 JEFFERSON ST	400	4	1	1	1	1	2	1927	06/04/1986	06/18/1986	TOR15-008A	C
86 - 3255	TOR0015	3	2303 JEFFERSON AVE	400	4	1	1	1	1	4	1927	02/11/1986	02/11/1987	TOR15-008A	C
77 -886063	TOR0015	3	1633 ACACIA	200	2	1	1	1	1	4	1928	12/01/1977	12/01/1977	TOR15-009	P
83 - 22793	TOR0015	3	BEHIND 1622 ACACIA	200	2	1	1	1	1	4	1927	08/22/1983	04/22/1984	TOR15-010	P

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84 - 51085	TOR0015	1	1614 ACACIA AV	200	2	1	1	1	1	4	1927	01/04/1984	01/04/1984	TOR15-010	P
91 - 15091	TOR0015	3	1621 S AMAPOLA AVE	200	2	1	1	1	1	2	1956	10/03/1991	10/03/1991	TOR15-012	C
91 - 7741	TOR0015	1	1542 POST AVE	200	2	1	1	1	1	4	1912	08/15/1991	08/15/1991	TOR15-013	C
81 - 11620	TOR0015	3	POST AVE	200	2	1	1	1	1	4	1912	07/07/1981	09/07/1981	TOR15-013	C
86 - 3132	TOR0015	1	I/S ALLEY N/CARSON ST & ALLEY W	200	2	1	1	1	1	4	1924	01/20/1986	01/20/1986	TOR15-015	C
89 - 40331	TOR0015	3	2264 SONOMA ST	200	2	1	1	1	1	4	1924	08/28/1989	02/28/1990	TOR15-015	C
86 - 38890	TOR0015	3	1627 AMAPOLA	200	2	1	1	1	1	4	1924	06/23/1986	06/23/1986	TOR15-015	C
86 - 37850	TOR0015	2	I/S ALLEY N/CARSON ST & ALLEY	200	2	1	1	1	1	4	1924	01/20/1986	01/20/1986	TOR15-015	C
84 - 39787	TOR0009	3	1512 EL PRADO AVE	200	2	1	1	1	1	2	1950	12/14/1984	12/14/1984	TOR16-001	P
84 - 30764	TOR0016	2	1515 ARLINGTON	200	2	1	1	1	1	4	1912	03/09/1984	03/09/1984	TOR16-001	P
80 - 1869	TOR0016	3	1528 EL PRADO	200	2	1	1	1	1	2	1912	06/18/1980	07/18/1980	TOR16-001	P
84 - 39786	TOR0009	3	1512 EL PRADO AV	200	2	1	1	1	1	2	1950	12/14/1984	12/14/1984	TOR16-001	P
83 - 50532	TOR0016	3	1613 CRAVENS AVE	300	3	1	1	1	1	4	1912	06/24/1983	06/24/1983	TOR16-004	C
81 - 18595	TOR0016	2	1617 CRAVENS	300	3	1	2	1	1	4	1912	06/03/1981	06/03/1981	TOR16-004	C
82 - 21742	TOR0016	2	1613 1/2 CRAVEN	300	3	1	1	1	1	4	1912	06/07/1982	06/21/1982	TOR16-004	C
90 - 10100	TOR0016	3	1613 CRAVENS AV	300	3	1	1	1	1	4	1912	12/27/1990	01/27/1991	TOR16-004	C
77 -876993	TOR0016	3	1600 CABRILLO	600	6	1	1	1	1	4	1913	08/01/1977	08/01/1977	TOR16-010	P
83 - 50588	TOR0016	3	N/E CORNER BORDER AVE & CARSON	600	6	1	1	1	1	1	1941	07/13/1983	07/13/1983	TOR16-012	C
77 -908168	TOR0016	1	I/S CAZSON/BORDER AT RR CROSSING	600	6	1	1	1	1	2	1941	06/01/1977	06/01/1977	TOR16-012	C
83 - 37786	TOR0016	2	N/E CORNER BORDER AVE & CARSON AV	600	6	1	1	1	1	1	1941	06/29/1983	07/29/1983	TOR16-012	C
80 - 8376	TOR0016	1	1905 ABALONE	400	4	1	1	1	1	4	1913	03/18/1980	03/18/1980	TOR16-015	P
84 - 56785	TOR0016	3	1740 ABALONE AV	400	4	1	1	1	1	3	1913	05/15/1984	02/15/1985	TOR16-015	P
86 - 3583	TOR0016	3	1805 ABALONE	400	4	1	1	1	1	4	1923	05/01/1986	05/01/1987	TOR16-015	P
76 -848781	TOR0016	3	1740 ABALONE AVE	400	4	1	1	1	1	4	1913	09/01/1976	09/01/1976	TOR16-015	P
79 -150273	TOR0016	3	1740 ABALONE	400	4	1	1	1	1	4	1913	08/01/1979	08/01/1979	TOR16-015	P
76 -848756	TOR0016	3	1905 ABALONE	400	4	1	1	1	1	4	1913	07/01/1976	07/01/1976	TOR16-015	P
86 - 3584	TOR0016	3	1907 ABALONE	400	4	1	1	1	1	4	1913	05/01/1986	05/01/1987	TOR16-015	P
81 - 11367	TOR0016	3	OPPOSITE OF 1744 ABALONE	400	4	1	1	1	1	4	1913	06/04/1981	06/04/1982	TOR16-015	P
81 - 11366	TOR0016	3	1809 ABALONE	400	4	1	1	1	1	4	1913	06/04/1981	10/04/1981	TOR16-015	P
79 -150271	TOR0016	3	1820 ABALONE	400	4	1	2	1	4	4	1913	08/01/1979	08/01/1979	TOR16-015	P
87 - 11771	TOR0016	2	1915 ABALONE AVE	400	4	1	1	1	1	4	1913	05/08/1987	05/08/1987	TOR16-015	P
77 -876989	TOR0016	3	1905 ABALONE AVE	400	4	1	1	1	1	4	1913	08/01/1977	08/01/1977	TOR16-015	P
79 -150270	TOR0016	3	ABALONE AVE 60' N/N PL 220TH ST	400	4	1	1	1	1	4	1913	08/01/1979	08/01/1979	TOR16-015	P
88 - 20159	TOR0016	3	1907 ABALONE AVENUE	400	4	1	1	1	1	4	1951	05/04/1988	06/04/1988	TOR16-015A	C
86 - 38623	TOR0016	2	1962 CARSON	300	3	1	1	1	1	4	1968	05/08/1986	05/08/1986	TOR16-016	C
76 -844796	TOR0016	2	1720 GRAMERCY AVE	300	3	1	1	1	1	4	1912	07/01/1976	07/01/1976	TOR16-016	C
73 -570305	TOR0016	1	1719 GRAMERCY AVE	300	3	1	1	1	1	4	1912	07/01/1973	07/01/1973	TOR16-016	C
88 - 55465	TOR0016	1	1715 CABRILLO AVE	300	3	1	1	1	6	4	1912	05/02/1988	05/02/1988	TOR16-016	C
81 - 11368	TOR0016	3	I/S CABRILLO & ALLEY S/CARSON	300	3	1	1	1	1	4	1912	06/04/1981	07/04/1981	TOR16-016	C
78 -935947	TOR0016	3	I/S OF ALLEY S OF CARSON/ANDRED A	300	3	1	1	1	1	4	1912	08/01/1978	08/01/1978	TOR16-016	C
75 -719465	TOR0016	1	2029 BORDER	200	2	1	1	1	1	4	1913	07/01/1975	07/01/1975	TOR16-016D	C
80 - 8833	TOR0016	2	2113 BORDER AVE	200	2	1	1	1	1	4	1913	06/16/1980	06/16/1980	TOR16-016D	C
90 - 10090	TOR0016	3	1733 BORDER AV	200	2	1	1	1	1	4	1913	12/19/1990	12/19/1991	TOR16-017	P
86 - 38316	TOR0016	3	1820 CABRILLO	200	2	1	1	1	1	4	1913	03/26/1986	03/26/1986	TOR16-017	P
90 - 10088	TOR0016	3	218TH ST & BORDER AV	200	2	1	1	1	1	4	1913	12/19/1990	12/19/1990	TOR16-017	P
90 - 2300	TOR0016	3	ALLEY W/O BORDER AV	200	2	1	1	1	1	4	1913	03/12/1990	11/12/1990	TOR16-017	P
78 -989851	TOR0016	2	1914 W 218TH ST.	200	2	1	1	1	1	4	1968	10/01/1978	10/01/1978	TOR16-021	P
76 -800623	TOR0017	2	2063 LINCOLN AVE	200	2	1	1	1	1	4	1926	06/01/1976	06/01/1976	TOR17-005	P
79 - 72658	TOR0017	3	2409 ARLINGTON AVE	200	2	1	1	1	1	4	1926	03/01/1979	03/01/1979	TOR17-005	P
75 -744164	TOR0017	3	2409 ARLINGTON AVE	200	2	1	1	1	1	4	1923	10/01/1975	10/01/1975	TOR17-005	P

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79 - 72681	TOR0017	3	S/E COR SANTA FE & ARLINGTON	400	4	1	1	1	1	4	1922	04/01/1979	04/01/1979	TOR17-006	P
76 -845298	TOR0017	3	ARLINGTON & PLAZA DEL AMO	400	4	1	1	1	1	4	1922	08/01/1976	08/01/1976	TOR17-006A	C
84 - 38699	TOR0017	3	N/E COR OF LINCOLN & ARLINGTON AV	400	4	1	4	1	1	4	1922	03/23/1984	03/23/1984	TOR17-006A	C
86 - 38883	TOR0017	3	2410 ARLINGTON AVE	400	4	1	1	1	1	4	1922	06/20/1986	06/20/1986	TOR17-006A	C
79 -105707	TOR0017	3	2409 ARLINGTON	400	4	1	1	1	1	4	1922	10/01/1979	10/01/1979	TOR17-006A	C
78 -976047	TOR0017	1	2202 ARLINGTON AVE	400	4	1	1	1	1	4	1956	11/01/1978	11/01/1978	TOR17-006B	P
90 - 2358	TOR0017	3	2030 SANTA FE AVE	300	3	1	1	1	1	4	1930	05/11/1990	02/11/1991	TOR17-008B	C
83 - 29958	TOR0017	2	1966 1/2 PLAZA DEL AMO	200	2	1	1	1	1	4	1941	05/13/1983	05/13/1983	TOR17-012A	C
78 -992455	TOR0017	2	1912 PLAZA DELAMO	200	2	1	1	1	1	4	1916	09/01/1978	09/01/1978	TOR17-014A	C
79 - 72659	TOR0017	3	1912 PLAZA DEL AMO	200	2	1	1	1	1	4	1916	03/01/1979	03/01/1979	TOR17-014A	C
85 - 1065	TOR0017	3	1912 PLAZA DEL AMO	200	2	1	1	1	1	4	1965	05/15/1985	01/15/1986	TOR17-015	C
83 - 22621	TOR0017	3	2303 ANDREO	200	2	1	1	1	1	4	1965	05/17/1983	01/17/1984	TOR17-016B	C
78 -933845	TOR0017	1	ALLEY S/O PLAZA DEL AMO	200	2	1	1	1	1	4	1916	07/01/1978	07/01/1978	TOR17-017	P
78 -990402	TOR0017	1	ALLEY S/O PLAZA DEL AMO &	200	2	1	1	1	1	4	1916	07/01/1978	07/01/1978	TOR17-017	P
78 -914046	TOR0017	1	2408 CABRILLO	200	2	1	1	1	1	4	1916	06/01/1978	06/01/1978	TOR17-017	P
78 -990256	TOR0017	1	1880 PLAZA DEL AMO	200	2	1	1	1	1	4	1916	06/01/1978	06/01/1978	TOR17-017	P
83 - 22627	TOR0017	3	835 MARINETTE AVE	300	3	1	1	1	1	2	1949	05/17/1983	02/17/1984	TOR17-023	C
78 -990274	TOR0017	2	2219 BORDER AVE	200	2	1	1	1	1	4	1913	06/01/1978	06/01/1978	TOR17-027	P
77 -876994	TOR0017	3	2213 BORDER AVE	200	2	1	1	1	1	4	1913	08/01/1977	08/01/1977	TOR17-027	P
78 -990257	TOR0017	2	2230 CABRILLO	200	2	1	1	1	1	4	1913	06/01/1978	06/01/1978	TOR17-027	P
78 -914049	TOR0017	1	2207 BOLDER AVE	200	2	1	1	1	1	4	1913	06/01/1978	06/01/1978	TOR17-027	P
84 - 51725	TOR0017	3	1780 PLAZA DEL AMO	400	4	1	1	1	1	4	1923	07/31/1984	08/31/1984	TOR17-031	C
79 -150264	TOR0017	3	22500 BLOCK WESTERN	200	2	1	1	1	1	2	1949	09/01/1979	09/01/1979	TOR17-031A	C
77 -908120	TOR0017	1	22501 WESTERN AVE	200	2	1	1	1	1	2	1949	07/01/1977	07/01/1977	TOR17-031A	C
83 - 22605	TOR0017	3	22501 WESTERN	400	4	1	1	1	1	2	1981	06/15/1983	07/15/1983	TOR17-031C	C
79 -150265	TOR0017	3	1700 BLOCK PLAZA DEL AMO	800	8	1	1	1	1	2	1949	09/01/1979	09/01/1979	TOR17-032A	C
81 - 18581	TOR0017	3	NORTHWEST CORNER PLAZA DEL AMO &	200	2	1	1	1	1	2	1952	06/02/1981	06/02/1981	TOR17-035	C
85 - 1068	TOR0017	3	1921 222ND ST	200	2	1	1	1	1	2	1922	05/15/1985	02/15/1986	TOR17-040	C
71 -256014	TOR0009	1	LLEWELLYN & TORRANCE BL	200	2	1	1	2	1	4	1931	05/01/1971	05/01/1971	TOR09-001	P
72 -460197	TOR0009	2	ALLEY W/CRAVENS AVE	200	2	1	1	2	1	4	1913	06/01/1972	06/01/1972	TOR09-001	C
74 -704347	TOR0009	3	ALLEY BETWEEN ENGRACIA AND POST	300	3	1	4	2	6	4	1912	12/01/1974	12/01/1974	TOR09-004A	P
86 - 26735	TOR0009	1	1423 POST AV	300	3	1	1	2	1	3	1976	08/18/1986	08/18/1986	TOR09-004A	C
84 - 51729	TOR0009	3	2014 TORRANCE BLVD XST SARTORI	300	3	1	1	2	1	4	1949	08/10/1984	08/10/1984	TOR09-004C	P
70 -127157	TOR0009	2	2ND ALLEY S/TOR BLVD AND W/POST A	200	2	1	1	2	1	4	1913	09/01/1970	09/01/1970	TOR09-005	P
82 - 22028	TOR0009	3	1330 EL PRADO	200	2	1	4	2	5	4	1949	09/16/1982	09/16/1983	TOR09-008	C
80 - 2097	TOR0009	3	1414 CRAVENS	200	2	1	1	2	1	4	1954	09/05/1980	03/05/1981	TOR09-009	C
74 -686428	TOR0009	3	1407 SARTORI	300	3	1	4	2	1	2	1949	08/01/1974	08/01/1974	TOR09-010	C
70 -127076	TOR0009	2	1434 MARCELINA	200	2	1	1	2	1	4	1913	09/01/1970	09/01/1970	TOR09-011	P
70 -127077	TOR0009	2	ALLEY E/O MARCELINA	300	3	1	1	2	1	4	1912	09/01/1970	09/01/1970	TOR09-011	P
70 -127086	TOR0009	2	1434 MARCELINA	300	3	1	1	2	1	4	1912	09/01/1970	09/01/1970	TOR09-011	P
83 - 30124	TOR0009	3	N/E CORNER ALLEY E/O SARTORI	200	2	1	1	2	1	1	1926	07/20/1983	07/20/1983	TOR09-013A	C
89 - 40449	TOR0009	3	ALLEY W/O VAN NESS AT TORRANCE BL	200	2	1	1	2	1	3	1927	08/22/1989	08/22/1990	TOR09-013A	C
71 -190166	TOR0009	2	TOR BL E/ LLEWELLYN	800	8	1	6	2	6	4	1912	05/01/1971	05/01/1971	TOR09-015	P
71 -208016	TOR0009	1	1853 TORR BLVD	800	8	1	4	2	1	4	1912	10/01/1971	10/01/1971	TOR09-015	P
85 - 35024	TOR0010	2	1313 DATE	100	1	1	1	2	1	1	1939	01/10/1985	01/10/1985	TOR10-005D	C
71 -111119	TOR0010	1	I/S CRENSHAW BL ELDORADO ST	300	3	1	1	2	1	4	1924	07/01/1971	07/01/1971	TOR10-006	P
90 - 2616	TOR0010	3	2515 EL DORADO ST	200	2	1	1	2	1	3	1927	10/30/1990	12/30/1990	TOR10-007A	C
72 -190437	TOR0010	1	2555 SONOMA ST	200	2	1	1	2	1	4	1924	06/01/1972	06/01/1972	TOR10-008B	C
78 -914288	TOR0010	1	2555 SONOMA	200	2	1	1	2	1	4	1935	07/01/1978	07/01/1978	TOR10-009	P
72 -459902	TOR0010	3	1512 DATE AVE	200	2	1	1	2	1	4	1924	08/01/1972	08/01/1972	TOR10-009	P

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72 -460371	TOR0010	1	1416 CRENSHAW BLVD	200	2	1	1	2	1	4	1927	07/01/1972	07/01/1972	TOR10-011	P
73 -503780	TOR0010	3	2371 TORR BLVD.	300	3	1	1	2	1	4	1927	06/01/1973	06/01/1973	TOR10-012C	C
82 - 21720	TOR0010	3	1104 AMAPOLA	200	2	1	1	2	1	3	1924	06/09/1982	09/09/1982	TOR10-012D	P
73 -214711	TOR0010	3	2325-23-TORR. BL. ALLEY N/O TORR.	200	2	1	3	2	6	4	1922	07/01/1973	07/01/1973	TOR10-012D	P
82 - 21427	TOR0010	3	1104 AMAPOLA	200	2	1	1	2	1	3	1924	06/09/1982	07/09/1982	TOR10-012D	P
84 - 31450	TOR0010	2	811 BEECH AVE	200	2	1	2	2	1	4	1928	11/16/1984	11/30/1984	TOR10-013	P
86 - 60326	TOR0010	3	1020 ACACIA AVE	200	2	1	1	2	2	4	1927	11/26/1986	11/26/1987	TOR10-015	P
73 -503935	TOR0010	2	2263 TORR BLVD	200	2	1	1	2	1	4	1917	06/01/1973	06/01/1973	TOR10-019B	P
71 -190878	TOR0010	1	1217 BEECH AVE	200	2	1	1	2	1	4	1927	09/01/1971	09/01/1971	TOR10-024A	P
71 -190876	TOR0010	1	1217 BEECH AVE	200	2	1	1	2	1	4	1927	09/01/1971	09/01/1971	TOR10-024A	P
82 - 22170	TOR0010	3	1230 CRENSHAW BLVD	200	2	1	1	2	1	4	1927	12/17/1982	02/17/1983	TOR10-024A	P
83 - 37585	TOR0015	3	1424 BEECH AVE	200	2	1	1	2	1	4	1927	04/25/1983	04/25/1983	TOR10-025	P
73 -643336	TOR0010	3	2414 SONOMA ST	200	2	1	1	2	1	4	1927	12/01/1973	12/01/1973	TOR10-025	P
78 -933836	TOR0010	1	1221 ACACIA AVE	200	2	1	1	2	1	4	1927	06/01/1978	06/01/1978	TOR10-025	P
71 -190225	TOR0010	3	ELDORADO SE & ALLEY E/O ACACIA	200	2	1	1	2	1	4	1927	10/01/1971	10/01/1971	TOR10-026	P
84 - 51893	TOR0010	3	1315 - B MADRID	200	2	1	4	2	5	2	1927	09/20/1984	09/20/1984	TOR10-026	P
70 -188101	TOR0010	1	1319 ARLINGTON	200	2	1	1	2	1	4	1922	10/01/1970	10/01/1970	TOR10-036	P
92 - 82210	TOR0010	3	1422 ENGRACIA AV	300	3	1	1	2	1	4	1900	08/12/1992	08/12/1992	TOR10-039A	C
78 -976080	TOR0010	2	2166 TORR BLVD	200	2	1	1	2	1	4	1922	10/01/1978	10/01/1978	TOR10-040D	P
73 -503939	TOR0010	2	1213 COTA AVE	200	2	1	1	2	1	4	1921	06/01/1973	06/01/1973	TOR10-040D	P
74 -686329	TOR0010	3	2208 TORRANCE BLVD	200	2	1	1	2	1	4	1922	07/01/1974	07/01/1974	TOR10-040E	P
84 - 7451	TOR0010	1	ON TORRANCE BLVD 27' W/W AMAPOLA	200	2	1	1	2	1	4	1921	09/11/1984	09/11/1984	TOR10-102	P
84 - 7453	TOR0010	1	ON TORRANCE BLVD 64 W/W AMAPOLA	200	2	1	4	2	1	4	1921	09/11/1984	09/11/1984	TOR10-102	P
77 -844466	TOR0015	1	1726 DATE AVE	200	2	1	1	2	1	4	1927	08/01/1977	08/01/1977	TOR15-003A	C
72 -208364	TOR0015	1	2303 JEFFERSON	400	4	1	1	2	1	4	1927	05/01/1972	05/01/1972	TOR15-008A	C
89 - 40348	TOR0015	3	2303 JEFFERSON	400	4	1	1	2	3	4	1927	08/15/1989	08/15/1990	TOR15-008A	C
79 -105354	TOR0015	1	2414 SONOMA ST	200	2	1	1	2	1	4	1972	08/01/1979	08/01/1979	TOR15-009	P
86 - 37998	TOR0015	3	1631 AMAPOLA AVE	300	3	1	1	2	1	4	1921	02/10/1986	02/10/1986	TOR15-012B	C
71 -179615	TOR0015	3	1614 COTA AVE	300	3	1	6	2	1	4	1912	05/01/1971	05/01/1971	TOR15-012C	C
92 - 80532	TOR0015	2	CARSON ST & COTA AV	200	2	1	1	2	1	2	1913	03/18/1992	03/18/1992	TOR15-015	C
78 -909798	TOR0016	1	1452 EL PRADO	200	2	1	1	2	3	4	1912	06/01/1978	06/01/1978	TOR16-001	P
78 -935946	TOR0016	3	N/E CORNER/CARSON & ALLEY E CABRI	600	6	1	1	2	6	1	1913	08/01/1978	08/01/1978	TOR16-010	P
72 -190415	TOR0016	1	1871 CARSON ST	600	6	1	1	2	1	4	1941	02/01/1972	02/01/1972	TOR16-011	C
71 -180366	TOR0016	3	BORDER AV AND CARSON STREET	400	4	1	1	2	1	4	1918	03/01/1971	03/01/1971	TOR16-013	P
72 -459961	TOR0016	2	1645 ARLINGTON	400	4	1	1	2	1	4	1922	10/01/1972	10/01/1972	TOR16-014	P
71 -180357	TOR0016	3	2118 CARSON STREET	400	4	1	4	2	4	4	1912	03/01/1971	03/01/1971	TOR16-014	P
71 -180358	TOR0016	3	1645 ARLINGTON AVENUE	400	4	1	1	2	1	4	1912	03/01/1971	03/01/1971	TOR16-014	P
85 - 35245	TOR0016	3	1746 ABALONE AVE	400	4	1	1	2	1	3	1913	02/06/1985	02/06/1985	TOR16-015	P
73 -684156	TOR0016	3	1740 ABALONE AV	400	4	1	1	2	1	4	1913	12/01/1973	12/01/1973	TOR16-015	P
80 - 1867	TOR0016	3	1740 ABALONE AVE	400	4	1	1	2	1	3	1913	06/18/1980	07/18/1980	TOR16-015	P
71 -188370	TOR0016	3	1720 CABRILLO	300	3	1	1	2	1	4	1919	01/01/1971	01/01/1971	TOR16-016	C
71 -190956	TOR0016	2	1718 ANDREO	300	3	1	1	2	1	4	1912	09/01/1971	09/01/1971	TOR16-016	C
74 -684175	TOR0016	3	2012 CABRILLO	200	2	1	1	2	1	4	1913	05/01/1974	05/01/1974	TOR16-016C	P
74 -684174	TOR0016	3	2025 BORDER AV	200	2	1	1	2	1	4	1913	05/01/1974	05/01/1974	TOR16-016C	P
73 -502783	TOR0016	3	2104 CABRELO AVE	200	2	1	1	2	1	4	1913	05/01/1973	05/01/1973	TOR16-016D	C
71 -180373	TOR0016	3	2100 BLK/BORDER AVENUE	400	4	1	1	2	1	4	1918	04/01/1971	04/01/1971	TOR16-016D	C
71 -180371	TOR0016	3	2117 BORDER AVENUE	400	4	1	1	2	1	4	1918	04/01/1971	04/01/1971	TOR16-016D	C
90 - 11358	TOR0016	1	1817 BORDER AV	200	2	1	1	2	1	4	1913	12/19/1990	12/19/1990	TOR16-017	P
71 -188206	TOR0016	2	1876 BORDER	200	2	1	1	2	1	4	1923	02/01/1971	02/01/1971	TOR16-017	P
91 - 10111	TOR0016	3	ALLEY EAST OF CABRILLO	200	2	1	1	2	3	4	1913	01/08/1991	01/08/1991	TOR16-017	P

MAIN REPAIR LEAKS - MODIFIED LEAK REPAIR ORDER DATABASE

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90 - 10092	TOR0016	3	1907 BORDER AV	200	2	1	4	2	1	4	1913	12/19/1990	12/19/1991	TOR16-017	P
90 - 10091	TOR0016	3	1720 CABRILLO AV	200	2	1	1	2	1	4	1957	12/19/1990	01/19/1991	TOR16-017A	P
74 -686192	TOR0016	1	1720 MARTINA	300	3	1	1	2	1	4	1913	04/01/1974	04/01/1974	TOR16-018	P
72 -460196	TOR0017	2	ALLEY S/CARSON ST	300	3	1	1	2	1	4	1913	06/01/1972	06/01/1972	TOR16-018	P
73 -513287	TOR0016	1	1743 CABRILLO	200	2	1	1	2	1	4	1912	03/01/1973	03/01/1973	TOR16-021	P
71 -192899	TOR0016	2	1917 19 W 218TH STREET	200	2	1	1	2	1	4	1912	04/01/1971	04/01/1971	TOR16-021	P
71 -180361	TOR0016	2	1753 CABRILLO AVENUE	200	2	1	4	2	1	4	1912	05/01/1971	05/01/1971	TOR16-021	P
72 -460194	TOR0016	2	1723 MARTINA AVE	200	2	1	1	2	1	4	1913	06/01/1972	06/01/1972	TOR16-028	P
74 -704011	TOR0017	3	2067 LINCOLN AVE	200	2	1	1	2	1	4	1923	08/01/1974	08/01/1974	TOR17-005	P
71 -190782	TOR0017	2	2415 ARLINGTON	200	2	1	1	2	1	4	1926	11/01/1971	11/01/1971	TOR17-005	P
74 -643175	TOR0017	3	2503 ARLINGTON AVE	200	2	1	1	2	1	4	1923	07/01/1974	07/01/1974	TOR17-005A	P
76 -853719	TOR0017	3	ARLINGTON & PLAZA DEL AMO	400	4	1	4	2	6	4	1922	09/01/1976	09/01/1976	TOR17-006A	C
73 -570307	TOR0017	3	EAST SIDE OF ARLINGTON&PLAZADELAM	400	4	1	1	2	1	4	1922	08/01/1973	08/01/1973	TOR17-006A	C
85 - 1066	TOR0017	3	2732 ANDREO	400	4	1	1	2	6	4	1923	05/15/1985	04/15/1986	TOR17-009	C
85 - 1064	TOR0017	3	2407 GRAMERCY AVE	100	1	1	1	2	3	1	1943	05/15/1985	01/15/1986	TOR17-011	C
78 -992421	TOR0017	3	1912 PLAZA DEL AMO	200	2	1	1	2	1	4	1916	11/01/1978	11/01/1978	TOR17-014A	C
74 -704013	TOR0017	3	1912 PLAZA DEL AMO	200	2	1	1	2	1	4	1965	10/01/1974	10/01/1974	TOR17-015	C
91 - 7617	TOR0017	1	2413 CABRILLO ALLEY BEHIND	200	2	1	1	2	1	1	1941	05/14/1991	05/14/1991	TOR17-018	C
79 -150267	TOR0017	3	2213 BORDER	200	2	1	1	2	1	3	1913	08/01/1979	08/01/1979	TOR17-027	P
81 - 18659	TOR0017	3	N/W CORN O/PLAZA DE AMO/WESTERN	400	4	1	1	2	2	2	1949	06/17/1981	06/17/1981	TOR17-031C	P
78 -914045	TOR0017	1	22501 WESTERN AVE	400	4	1	4	2	4	2	1949	07/01/1978	07/01/1978	TOR17-031C	P
73 -684158	TOR0017	3	1600 226TH ST	200	2	1	1	2	1	2	1947	12/01/1973	12/01/1973	TOR17-036B	C
89 - 1514	TOR0009	1	1955 TORRANCE BL	600	6	1	1	4	1	4	1900	05/05/1989	05/05/1989	TOR09-014A	C
88 - 55883	TOR0015	1	2800 PLAZA DEL AMO	200	2	1	1	4	5	6	1988	07/20/1988	07/20/1988	TOR15-016C	C
87 - 12544	TOR0015	1	2573 PLAZA DEL AMO	200	2	1	1	4	3	6	1987	09/16/1987	09/16/1987	TOR15-016C	C
85 - 37220	TOR0015	1	PLAZA DEL AMO & CARSON	200	2	1	1	4	3	6	1985	10/14/1985	10/14/1985	TOR15-016C	C
88 - 55144	TOR0015	1	2800 PLAZA DEL AMO	200	2	1	1	4	6	6	1985	02/06/1988	02/06/1988	TOR15-016C	C
89 - 1672	TOR0017	1	2800 PLAZA DEL AMO	200	2	1	1	4	6	6	1989	06/13/1989	06/13/1989	TOR15-016C	C
77 -856089	TOR0009	3	POST AVE & ALLEY W/O SARTORI	300	3	1	3	8	3	4	1912	01/01/1977	01/01/1977	TOR09-004B	P
84 - 51900	TOR0010	1	I/S CRENSHAW & SONOMA	200	2	1	1	8	2	6	1983	09/21/1984	09/21/1984	TOR10-008	C
72 -460266	TOR0009	3	1414 CRAVENS	200	2	1	3	9	6	4	1950	08/01/1972	08/01/1972	TOR09-009	C
71 -190015	TOR0010	1	I/S ELDORADO CRENSHAW	300	3	1	4	9	6	4	1924	07/01/1971	07/01/1971	TOR10-006	P
91 - 15485	TOR0010	1	I/S ELDORADO ST CRENSHAW	200	2	1	3	9	6	4	1924	07/01/1971	07/01/1971	TOR10-011	P
84 - 39720	TOR0010	1	819 PORTOLA	200	2	1	1	9	1	4	1917	12/05/1984	12/05/1984	TOR10-020C	C
71 -190877	TOR0010	1	1217 BEECH AVE	200	2	1	3	9	6	4	1927	09/01/1971	09/01/1971	TOR10-024A	P
70 -127078	TOR0009	1	1304 EL PRADO	300	3	1	4	10	4	4	1949	09/01/1970	09/01/1970	TOR09-010	C
89 - 60025	TOR0010	3	2371 TORRANCE BLVD	300	3	1	4	10	4	4	1927	08/17/1989	08/17/1989	TOR10-012C	C
90 - 7035	TOR0010	1	1222 CRENSHAW BLVD	300	3	1	2	10	3	6	1983	02/09/1990	02/09/1990	TOR10-024A	C
75 -686098	TOR0010	2	1504 ENGRACIA AVE	300	3	1	1	10	4	4	1937	06/01/1975	06/01/1975	TOR10-039	P
71 -179616	TOR0015	1	1623 COTA AVE	200	2	1	4	10	6	4	1913	02/01/1971	02/01/1971	TOR15-015	C
87 - 11864	TOR0016	3	2061 - 220TH ST	200	2	1	2	10	1	1	1958	05/20/1987	05/20/1987	TOR16-026A	C
87 - 11125	TOR0016	3	1717 MARTINA AVE	200	2	1	4	10	6	1	1974	02/10/1987	02/10/1987	TOR16-028	P
83 - 22622	TOR0017	3	2409 ARLINGTON AVE	400	4	1	4	10	3	6	1922	05/17/1983	02/17/1984	TOR17-006A	C
76 -844861	TOR0009	1	1335 POST	200	2	1	6	11	5	4	1913	06/01/1976	06/01/1976	TOR09-003	P
90 - 2469	TOR0009	3	1318 S CRAVENS	200	2	1	1	11	6	3	1936	08/03/1990	08/03/1990	TOR09-003	P
79 - 51171	TOR0009	3	1326 1/2 ENGRACIA AVE	300	3	1	4	11	6	3	1976	01/01/1979	01/01/1979	TOR09-004A	C
81 - 11917	TOR0009	3	1331 POST AVE	300	3	1	4	11	1	4	1912	09/28/1981	12/28/1981	TOR09-004C	P
81 - 11915	TOR0009	3	1330 EL PRADO	200	2	1	3	11	6	2	1949	09/28/1981	10/28/1981	TOR09-008	C
80 - 2098	TOR0009	3	1330 EL PRADO	200	2	1	3	11	6	5	1949	09/05/1980	03/05/1981	TOR09-008	C
89 - 40450	TOR0009	3	ALLEY W/O VAN NESS AT ENGRACIA AV	200	2	1	3	11	6	1	1927	08/22/1989	08/22/1990	TOR09-013A	C

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80 - 9579	TOR0009	1	1920 TORRANCE	200	2	1	4	11	6	4	1936	11/07/1980	11/07/1980	TOR09-013B	C
84 - 56812	TOR0009	3	900 VAN NESS	600	6	1	4	11	6	2	1912	03/12/1984	01/12/1985	TOR09-014A	C
86 - 38274	TOR0009	2	1010 VAN NESS	600	6	1	1	11	6	4	1912	03/20/1986	04/03/1986	TOR09-014A	C
91 - 2929	TOR0009	3	923 VAN NESS AV	600	6	1	4	11	6	4	1912	08/15/1991	11/15/1991	TOR09-014A	C
77 -856088	TOR0009	3	MULLIN & CABRILLO	600	6	1	2	11	1	4	1912	03/01/1977	03/01/1977	TOR09-014A	C
72 -412553	TOR0009	3	W/S MULLIN AVE	600	6	1	2	11	6	4	1953	02/01/1972	02/01/1972	TOR09-014A	C
86 - 38275	TOR0009	2	1010 VAN NESS	600	6	1	5	11	1	4	1913	03/20/1986	03/20/1986	TOR09-014A	C
71 -190349	TOR0009	3	VAN NESS AND TORR BL	800	8	1	4	11	6	4	1912	04/01/1971	04/01/1971	TOR09-014A	C
76 -856051	TOR0009	3	MULLIN & TORR BLVD	600	6	1	4	11	6	4	1971	06/01/1976	06/01/1976	TOR09-014B	C
82 - 22030	TOR0009	3	1200 CABRILLO	600	6	1	4	11	6	4	1913	09/16/1982	05/16/1983	TOR09-014C	C
92 - 82159	TOR0009	1	1250 S CABRILLO AV	600	6	1	4	11	1	4	1900	08/06/1992	08/06/1992	TOR09-014C	C
79 -135369	TOR0009	3	1328 CABRILLO	600	6	1	4	11	6	2	1925	11/01/1979	11/01/1979	TOR09-014D	C
87 - 11565	TOR0009	3	VAN NESS & MULLIN AVE	200	2	1	3	11	6	4	1945	04/15/1987	04/15/1987	TOR09-014E	C
80 - 2127	TOR0009	3	TORRANCE & HUBER ST	800	8	1	3	11	6	5	1922	11/10/1980	08/10/1981	TOR09-018	C
87 - 8876	TOR0009	3	213TH & CABRILLO	300	3	1	3	11	6	1	1951	08/21/1987	03/21/1988	TOR09-023	C
85 - 35500	TOR0009	3	1739 213 ST	300	3	1	3	11	6	2	1951	03/08/1985	03/08/1985	TOR09-023	C
84 - 56814	TOR0009	3	1739 213TH ST	300	3	1	3	11	6	2	1951	03/12/1984	01/12/1985	TOR09-023	C
81 - 11918	TOR0009	3	I/S 213ST & CABRILLO AVE	300	3	1	1	11	6	1	1951	09/28/1981	12/28/1981	TOR09-023	C
87 - 12392	TOR0009	3	9' S/N TORRANCE BLD & 272' W/W W	800	8	1	3	11	6	4	1945	08/11/1987	08/11/1987	TOR09-030A	C
88 - 61465	TOR0009	3	1619 GRAMERCY AVE	200	2	1	1	11	1	4	1936	08/18/1988	09/18/1988	TOR09-032	C
70 -127075	TOR0009	2	1628 CRAVENS	200	2	1	2	11	1	4	1913	09/01/1970	09/01/1970	TOR09-032	C
86 - 37927	TOR0010	3	1313 DATE AVE	200	2	1	6	11	1	4	1935	01/31/1986	01/31/1986	TOR10-005B	C
71 -111118	TOR0010	1	I/S ELDORADO CRENSHAW	300	3	1	2	11	1	4	1924	07/01/1971	07/01/1971	TOR10-006	P
73 -643335	TOR0010	3	I/S ALLEY S/TORR BL & E/CRENSHAW	200	2	1	3	11	6	4	1927	12/01/1973	12/01/1973	TOR10-007	C
84 - 7091	TOR0010	3	2515 ELDORADO	200	2	1	6	11	1	4	1926	11/19/1984	12/19/1984	TOR10-007A	C
78 -992401	TOR0010	1	ALLEY N/TORR E/CRENSHAW	200	2	1	3	11	6	4	1928	08/01/1978	08/01/1978	TOR10-013	P
86 - 60290	TOR0010	3	1103 BEECH AVE	200	2	1	3	11	6	4	1927	12/03/1986	05/03/1987	TOR10-013	P
90 - 10021	TOR0010	1	812 BEECH AVE	200	2	1	4	11	6	2	1939	10/30/1990	10/30/1990	TOR10-014A	C
82 - 28681	TOR0010	1	2310 SIERRA ST	200	2	1	6	11	1	4	1917	05/28/1982	05/28/1982	TOR10-016A	C
90 - 2619	TOR0010	3	2309 SIERRA AV	200	2	1	1	11	6	4	1917	10/30/1990	06/30/1991	TOR10-018A	C
89 - 1798	TOR0010	3	1011 PORTOLA	200	2	1	4	11	1	4	1917	07/17/1989	07/17/1989	TOR10-020A	C
84 - 39690	TOR0010	1	1103 PORTOLA AVE	200	2	1	1	11	1	4	1917	11/30/1984	11/30/1984	TOR10-020A	C
78 -933840	TOR0010	2	1217 ACACIA AVE	200	2	1	3	11	6	4	1917	06/01/1978	06/01/1978	TOR10-025	P
84 - 51914	TOR0010	3	1313 MADRID AVE	200	2	1	4	11	6	4	1921	09/25/1984	09/25/1984	TOR10-026	P
82 - 22000	TOR0010	2	1432 ENGRACIA AVE	300	3	1	4	11	1	2	1912	06/11/1982	06/25/1982	TOR10-039A	C
84 - 7093	TOR0010	3	1310 MANUEL AVE	300	3	1	4	11	1	4	1912	11/21/1984	12/21/1984	TOR10-039A	C
82 - 21999	TOR0010	3	W/SIDE ALLEY S/O ENGRACIA AVE	300	3	1	4	11	6	4	1912	06/11/1982	06/11/1983	TOR10-039A	C
78 -933843	TOR0010	2	1432 ENGRACIA AVE	300	3	1	2	11	1	4	1912	07/01/1978	07/01/1978	TOR10-039A	C
72 -460469	TOR0010	3	CRENSHAW BLVD. & ALLEY S/O TORRAN	300	3	1	3	11	6	4	1945	09/01/1972	09/01/1972	TOR10-040A	C
83 - 50595	TOR0010	2	2260 TORRANCE BLVD	200	2	1	2	11	1	4	1922	07/15/1983	07/15/1983	TOR10-040D	P
86 - 38081	TOR0015	3	CRENSHAW BLVD/CARSON ST	800	8	1	3	11	6	2	1924	02/24/1986	02/24/1986	TOR15-004B	P
86 - 37946	TOR0015	3	I/S CRENSHAW BL & JEFFERSON ST	400	4	1	3	11	6	4	1945	02/03/1986	04/03/1986	TOR15-008	C
81 - 18786	TOR0015	3	2341 JEFFERSON	400	4	1	6	11	1	4	1923	07/22/1981	07/22/1981	TOR15-008A	C
77 -800962	TOR0015	3	29 W/E CRENSHAW BL	400	4	1	3	11	6	4	1927	01/01/1977	01/01/1977	TOR15-008A	C
86 - 37869	TOR0015	3	N/W CORNER ALLEY N/CARSON &W/COTA	300	3	1	3	11	6	4	1924	01/22/1986	01/22/1986	TOR15-012B	C
77 -908347	TOR0015	1	2265 CARSON APT B	200	2	1	3	11	6	4	1924	06/01/1977	06/01/1977	TOR15-015	C
79 - 51151	TOR0015	3	1736 WATSON AVE	200	2	1	4	11	6	2	1946	01/01/1979	01/01/1979	TOR15-017B	C
88 - 20400	TOR0015	3	1729 MANUEL AVE	200	2	1	4	11	6	2	1950	08/30/1988	05/30/1989	TOR15-018A	C
85 - 39847	TOR0016	2	1532 EL PRADO AVE	200	2	1	4	11	2	4	1912	01/02/1985	01/16/1985	TOR16-001	P
83 - 50533	TOR0016	3	1613 CRAVENS	300	3	1	2	11	1	4	1912	06/24/1983	06/24/1983	TOR16-004	C

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90 - 10099	TOR0016	3	1613 CRAVENS AV	300	3	1	6	11	6	4	1912	12/27/1990	01/27/1991	TOR16-004	C
90 - 2299	TOR0016	3	1528 MARCELINA AV	300	3	1	1	11	1	2	1912	03/14/1990	11/14/1990	TOR16-004	C
89 - 1350	TOR0016	1	1619 GRAMERCY	200	2	1	1	11	1	4	1954	03/17/1989	03/17/1989	TOR16-007	C
78 -990285	TOR0016	2	1652 CABRILLO	600	6	1	4	11	6	4	1913	09/01/1978	09/01/1978	TOR16-010	P
77 -876991	TOR0016	3	ALLEY E/O CABRILLO N/O CARSON	600	6	1	3	11	6	5	1913	08/01/1977	08/01/1977	TOR16-010	P
76 -844795	TOR0016	2	1718 ANDREO	300	3	1	6	11	6	4	1912	07/01/1976	07/01/1976	TOR16-016	C
71 -180363	TOR0016	3	2015 BORDER AVENUE	200	2	1	2	11	1	4	1913	04/01/1971	04/01/1971	TOR16-016C	P
91 - 10167	TOR0016	2	1908 CABRILLO AVE	200	2	1	1	11	1	4	1900	03/05/1991	03/05/1991	TOR16-017	P
78 -990469	TOR0016	1	1914 W 218 ST.	200	2	1	4	11	6	5	1900	11/01/1978	11/01/1978	TOR16-021	P
79 -105706	TOR0017	3	2409 ARLINGTON	200	2	1	3	11	6	5	1923	10/01/1979	10/01/1979	TOR17-005	P
78 - 51056	TOR0017	3	2432 ARLINGTON AVE	400	4	1	4	11	6	4	1922	09/01/1978	09/01/1978	TOR17-006A	C
76 -685841	TOR0017	2	I/S PLAZA DEL AMO & ARLINGTON	300	3	1	3	11	5	4	1922	11/01/1976	11/01/1976	TOR17-006A	C
77 -908377	TOR0017	1	2220 ARLINGTON	400	4	1	3	11	6	4	1926	08/01/1977	08/01/1977	TOR17-006B	P
74 -704012	TOR0017	3	2202 ARLINGTON AVE	400	4	1	1	11	1	4	1956	09/01/1974	09/01/1974	TOR17-006B	P
87 - 80358	TOR0017	3	N/W SANTA FE & ANDREO	300	3	1	3	11	6	4	1930	05/11/1987	02/11/1988	TOR17-008B	C
74 -704015	TOR0017	3	N/W CORNER SANTA F	300	3	1	3	11	6	4	1930	09/01/1974	09/01/1974	TOR17-008B	C
89 - 40195	TOR0017	3	N/W COR ANDREO AVE & SANTA FE AV	300	3	1	3	11	6	2	1930	05/15/1989	04/15/1990	TOR17-008B	C
79 - 72656	TOR0017	3	I/S SANTA FE AVE & ANDREO AVE	300	3	1	3	11	6	4	1930	04/01/1979	04/01/1979	TOR17-008B	C
83 - 22626	TOR0017	3	SANTA FE & ANDREO	300	3	1	3	11	6	2	1930	05/17/1983	02/17/1984	TOR17-008B	C
84 - 30613	TOR0017	3	I/S GRAMMERCY & SEPULVEDA	200	2	1	3	11	6	4	1947	01/04/1984	01/04/1984	TOR17-010	P
91 - 2890	TOR0017	3	ALLEY W/O ANDREO & S/O PLAZA DEL	200	2	1	6	11	1	2	1941	05/14/1991	10/14/1991	TOR17-012A	C
87 - 80362	TOR0017	3	2443 ANDREO AVE	200	2	1	4	11	1	1	1941	05/11/1987	02/11/1988	TOR17-012A	C
86 - 3589	TOR0017	3	100 S/S PL OF 222ND ST	200	2	1	6	11	2	4	1913	05/12/1986	05/12/1987	TOR17-013	C
87 - 80361	TOR0017	3	1880 LINCOLN AVE	200	2	1	4	11	6	1	1948	05/11/1987	03/11/1988	TOR17-020	C
82 - 21741	TOR0017	3	2308 CABRILLO AVE	200	2	1	2	11	1	4	1913	06/09/1982	04/09/1983	TOR17-027	P
83 - 22604	TOR0017	3	2323 BORDER	200	2	1	6	11	1	2	1913	06/15/1983	02/15/1984	TOR17-027	P
79 - 72660	TOR0017	3	CABRILLO AVE 140' W/W BORDER	100	1	1	3	11	6	2	1965	04/01/1979	04/01/1979	TOR17-028	C
79 -990314	TOR0017	3	22501 WESTERN AVE	400	4	1	3	11	6	5	1923	02/01/1979	02/01/1979	TOR17-031	C
77 -908172	TOR0017	1	22501 S. WESTERN AVE	400	4	1	3	11	6	2	1949	06/01/1977	06/01/1977	TOR17-031C	P
90 - 2359	TOR0017	3	226TH & WESTERN	200	2	1	3	11	6	2	1964	05/11/1990	02/11/1991	TOR17-036A	C
91 - 2887	TOR0017	3	VALVE N/E COR 226TH & WESTERN	200	2	1	3	11	6	2	1949	05/07/1991	12/07/1991	TOR17-036A	C
82 - 22029	TOR0009	3	1409 CRAVENS AV	200	2	1	6	12	2	2	1937	09/16/1982	09/16/1983	TOR09-005	P
84 - 56811	TOR0009	3	1020 SARTONI ALLEY R/O	200	2	1	6	12	2	5	1927	03/12/1984	01/12/1985	TOR09-013A	C
81 - 11114	TOR0009	3	1426 CABRILLO AVE	600	6	1	6	12	2	5	1913	03/19/1981	02/19/1982	TOR09-014	P
80 - 2096	TOR0009	3	1502 CABRILLO	600	6	1	6	12	2	5	1913	09/05/1980	09/05/1981	TOR09-014	P
81 - 11115	TOR0009	3	S/E CORNER OF DOUBLE ST IN THE	600	6	1	6	12	2	5	1913	03/19/1981	02/19/1982	TOR09-014	P
80 - 2095	TOR0009	3	1420 CABRILLO	600	6	1	6	12	2	5	1913	09/05/1980	09/05/1981	TOR09-014	P
84 - 7387	TOR0010	3	1326 DATE AVE	200	2	1	6	12	2	5	1935	12/05/1984	04/05/1985	TOR10-005B	C
85 - 35069	TOR0010	3	2555 SONOMA AVC/DATE ST	200	2	1	6	12	2	5	1924	01/17/1985	04/17/1985	TOR10-008B	C
84 - 39630	TOR0010	3	815 BEECH ST	200	2	1	6	12	2	2	1928	11/20/1984	08/20/1985	TOR10-013	P
84 - 39601	TOR0010	2	917 BEECH AVE	200	2	1	1	12	2	4	1928	11/15/1984	11/29/1984	TOR10-013	P
78 - 25333	TOR0010	2	1016 BEECH AVE	200	2	1	1	12	2	4	1929	07/01/1978	07/01/1978	TOR10-014	P
86 - 60327	TOR0010	3	ALLEY E/OF ACACIA	200	2	1	6	12	2	4	1927	11/26/1986	11/26/1987	TOR10-015	P
84 - 7388	TOR0010	3	807 PORTOLA AVE	200	2	1	6	12	2	4	1917	12/05/1984	12/05/1985	TOR10-020C	C
84 - 7391	TOR0010	3	1327 ACACIA	200	2	1	6	12	2	4	1927	12/05/1984	12/05/1985	TOR10-025	P
84 - 7393	TOR0010	3	2325 SONOMA	200	2	1	6	12	2	4	1927	12/05/1984	12/05/1985	TOR10-027	P
84 - 7394	TOR0010	3	1307 PORTOLA	200	2	1	6	12	2	4	1921	12/05/1984	12/05/1985	TOR10-035A	P
84 - 7449	TOR0010	3	ON TORRANCE BLVD 2 W/W AMAPOLA	200	2	1	6	12	2	2	1921	09/11/1984	09/11/1985	TOR10-102	P
84 - 7452	TOR0010	3	ON TORRANCE BLVD 54 W/W AMAPOLA	200	2	1	6	12	2	2	1921	09/11/1984	09/11/1985	TOR10-102	P
84 - 7455	TOR0010	3	ALLEY W/AMAPOLA 15 S/MAIN TIE IN	200	2	1	6	12	2	2	1925	09/11/1984	09/11/1985	TOR10-102	P

MAIN REPAIR LEAKS - MODIFIED LEAK REPAIR ORDER DATABASE

Leak Order Number	ATLAS SHEET	LEAK PRIO	Address or Location	SIZE	DIAMETER (inches)	Facility	LEAK In	Cause	Repair Type	Material	Year Installed	Detect Date	Action Date	Pipeline Segment Number	Pipeline info (C=CURRENT P=PREVIOUS)
83 - 22724	TOR0017	3	2740 GRAMERCY AVE	200	2	1	6	12	2	5	1947	07/06/1983	01/06/1984	TOR17-010	P
83 - 22728	TOR0017	3	2756 GRAMERCY AVE	200	2	1	6	12	1	5	1947	07/06/1983	01/06/1984	TOR17-010	P
83 - 22727	TOR0017	3	IN GRAMERCY 150' N/NPL SEPULVEDA	200	2	1	6	12	2	5	1947	07/06/1983	01/06/1984	TOR17-010	P
83 - 22725	TOR0017	3	2741 GRAMERCY AVE	200	2	1	6	12	2	5	1947	07/06/1983	01/06/1984	TOR17-010	P
83 - 22726	TOR0017	3	2748 GRAMERCY AVE	200	2	1	6	12	2	5	1947	07/06/1983	01/06/1984	TOR17-010	P
83 - 22729	TOR0017	3	IN GRAMERCY 90'N/NPL O/SEPULVEDA	200	2	1	6	12	2	5	1947	07/06/1983	01/06/1984	TOR17-010	P
83 - 22723	TOR0017	3	2732 GRAMERCY AVE	200	2	1	6	12	2	5	1947	07/06/1983	01/06/1984	TOR17-010	P
88 - 20210	TOR0017	3	2213 BORDEN AVE	200	2	1	6	12	2	4	1913	05/18/1988	07/18/1988	TOR17-027	P
81 - 11347	TOR0017	3	22501 WESTEREN AVE TORRANCE	200	2	1	6	12	2	5	1949	06/10/1981	07/10/1981	TOR17-031A	C

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