Evaluation of graffiti countermeasures on highways

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EVALUATION OF GRAFFITI COUNTERMEASURES
ON HIGHWAYS

by

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Bachelor of Technology
Jawaharlal Nehru Technological University, India
2006

A thesis submitted in partial fulfillment
of the requirements for the

Master of Science Degree in Engineering
Department of Civil and Environmental Engineering
Howard R. Hughes College of Engineering

Graduate College
University of Nevada, Las Vegas
December 2008
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is approved in partial fulfillment of the requirements for the degree of
Master of Science in Civil Engineering

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ABSTRACT

Evaluation of Graffiti Countermeasures on Highways

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Graffiti is an ever-growing problem that taints the environment. It costs over $12 billion per year to remove graffiti in the United States. Highway structures are accessible to the public at all hours of the day. So, there is much likelihood that these structures would be tagged. Bridges, sound walls, retaining walls and traffic signs are the major highway structures maintained by state DOT that are affected by graffiti. The present research is to evaluate the graffiti countermeasures for the highway structures in Nevada. In the evaluation process, an inventory data of graffiti cases on the major highway structures in Las Vegas and Reno is collected. The data is analyzed for finding the impact of the preventive measures, accessibility and surroundings on the amount of graffiti. In the next step, a survey is conducted to the maintenance divisions of all state DOTs for their current practice of removing and preventing graffiti. The survey results are analyzed for identifying some countermeasures from different states. Several meetings are conducted with various anti-graffiti agencies in Las Vegas, Phoenix, and Los Angeles to identify the countermeasures of graffiti for highway structures. Finally, a spectrum of
countermeasures is collected from the results of literature review, inventory data analysis, survey and the meetings. A cost-benefit analysis of these countermeasures is conducted for finding the effectiveness of the countermeasures. The most effective countermeasures are recommended to Nevada Department of Transportation (NDOT).
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ACKNOWLEDGMENTS

Firstly, I would like to thank my advisor Dr. Hualiang (Harry) Teng for his support and encouragement throughout my master’s study. His patience and understanding nature inspired me from the beginning. With his continuous advice and direction, I successfully completed this thesis.

It is my pleasure to express my gratitude to my committee members Dr. Moses Karakouzian, Dr. Mohammed Kaseko and Dr. Ashok Singh for their friendly advices and support.

I am thankful to Vamsi Surapaneni, Dr. Mukund and Dr. Vinod for their help and guidance in my studies. I am grateful to my classmates Daniel, Saidi, Timur, Vidya, Avinash and Ahmed for making me confident and helping me in various aspects.

I would like to convey my thanks to my friends Inampudi, Chava, Krishna, Kartheek, Bobby, Sandeep and Phani for their valuable friendship and company.

I am indebted to my best friends Vamsi Vellanki and Anu for their precious emotional support and caring.

I would like to extend my heartfelt gratitude to my parents Samba Siva Rao and Maha Lakshmi; and my family members for their precious love and support.

Last but not least, I would like to thank my ardent friend Swathi for her immense love and caring, which make me possible to finish this thesis.
1.1 Introduction

According to San Diego Council (2000), graffiti is any unauthorized inscription, word, figure, picture, or design that is sprayed, marked, cut, posted, pasted or otherwise affixed, drawn or painted on any surface of public or private property. Graffiti vandalism is an ever-growing and expensive problem in the United States. It was originated in New York in the 1960s. At that time, gangs in the city started writing their names to mark their territory and teens began writing their nicknames and street numbers on walls competitively (Wylie, 1999). Later, with the introduction of spray paints, permanent markers and other vast technologies, taggers were allowed to make vandalism on most inaccessible areas also and the problem was escalated. To deal with this problem, it is desirable to know why and how taggers make graffiti vandalism. According to the Australian research on graffiti and its creators (Halsey and Young, 2002), the following facts were summarized based on interviewing 44 taggers.

- Taggers create graffiti to get ‘fame’ or ‘recognition’ or ‘reputation’ for their gang and gang members. It also evokes strong feelings of self-esteem, satisfaction and happiness among them.

- Lack of proper legitimate activities for young people gives them the chance to repeat graffiti.
• Taggers want their graffiti to be seen not only by public but also by the other tagger gangs. That is the reason why they create graffiti in most abandoned places also.

• A cockatoo (look out person) will be there in every gang to look out for any cameras or other police informers. If he or she thinks that any camera is there in the vicinity of the place they planned to tag, he or she will first destroy the camera by spraying on it and then activate his gang members if there were any police informers.

• Many of the taggers will record their activities and maintain the entire database of their tagging activities, which consists of when, where and how they tagged, and the paints used in tagging. They will also have the videos and pictures of their tagging so that they can exchange them among different gangs.

• Taggers have a vast technology even including a machine of robot technology to create graffiti on the places to which they have no access. The machine consists of a spray painter that will create graffiti, based on the program written in the computer attached to it. Usually, taggers will take the videos when the machine is creating graffiti.

• Majority of the taggers are introduced to graffiti vandalism through their friends and acquaintances.

• Once the taggers become used to graffiti vandalism, they will not stop it unless they were punished with imprisonment or strong penalties.

• It is very difficult for practiced or hard-core taggers to resist their urge to tag.
• Taggers will have strict rules about the type of graffiti, their area of tagging and their involvement in other types of criminal activities.

The harm caused by graffiti will be in terms of property damage and fear of crime, which is the main focus for state and central government (Callinon, 2002). Graffiti in a community degrades the social status of the community and diminishes the value of the property. It encourages loitering, littering, shoplifting of materials needed for graffiti such as paints, markers and more other crimes in the community. Graffiti on public transportation systems such as buses and trains may reduce the ridership and increase fear among the travelers. Graffiti on the highways is not only an eye sore to the traveling public, it presents a hazard to the perpetrator and a liability exposure for transportation agencies because highway structures span high elevations and are in close proximity to motor vehicle traffic (Eck and Martinelli, 1998).

It costs over $12 billion per year to remove graffiti on various facilities in the country. The high removal costs and more work hours for removal reflect the intensity of the problem. The facilities affected by graffiti include residential and commercial buildings, community division walls, street walls, channels, and the transportation facilities such as bridges, sound walls, retaining walls, traffic signs, sign poles, bus shelters, and public transport. The graffiti on these facilities will be cleaned by different agencies such as cities, counties and state Departments of Transportation (DOTs). Cities and counties clean graffiti on community division walls, street walls, grocery stores, traffic signs, sign poles, and residential buildings, while as DOTs clean graffiti on highway infrastructure such as bridges, sound walls, retaining walls and traffic signs. The removal techniques depend on the types and locations of surfaces affected by graffiti and
the type of paints used by the taggers. Painting over, water blasting, sand blasting, and chemical removal are the popular removal techniques adopted by different states. ‘Painting over’ is proved to be most economical when compared to the other techniques. Different states would have different graffiti removal policies. Some states have 24-hour graffiti abatement policy; some have 48-hour policy, and some others have 72-hour policy. Most of the states have policy of removing graffiti that was offensive, as soon as notified.

In some states, some proactive preventive measures are in use to eradicate graffiti completely. However, the effectiveness of these measures may vary from state to state. These measures may be classified as design modifications to the structures, technology based, and adopting anti-graffiti activities. Design modifications include installing fencing to bridges and on the corners of sound walls, landscaping the sound walls, installing rat guards and graffiti shields to the traffic sign poles and traffic signs. Technology based measures include installing security cameras and adopting spectrometers for color matching. Anti-graffiti activities include educational awareness, social awareness, community service, counseling programs to the taggers, encouraging citizen reporting, strong punishments, law enforcement, and maintaining anti-graffiti website. The punishments to taggers include fines, imprisonment, canceling drivers’ license and community service. In fact, graffiti is not a single ones problem. It is a social problem costing a huge amount of tax dollars for its removal and recovering the damages caused by it. Prevention would be possible if the people, police, government organizations, schools and private agencies fight together to get rid of it.
To mitigate the graffiti problem, several researches were conducted in the past. A research was conducted by the West Virginia University in 1998 to mitigate graffiti that was particularly on highway structures. In this research, a survey was conducted to maintenance divisions of all state highway agencies to assess the nature and extent of the graffiti problem and to identify the graffiti removal and preventive techniques. The results of this research showed that graffiti is a serious problem on all highway agencies in the United States and approximately 12% of the highways are affected by graffiti. It has also identified that the occurrence of graffiti was more prevalent in urban areas. The factors that make the highway structures attractive to taggers were also recognized. These factors include the structure’s visibility, surface properties and accessibility to the structures. Graffiti removal techniques that were identified in this research were ‘paint over’ and ‘water blasting using high pressure water sprays’. However, water-blasting technique was not used by many of the highway agencies as it could damage the surface and the removal was also not effective. The preventive measures that were identified include the design modifications to reduce the accessibility to the structures, applying anti-graffiti coatings, which is more expensive, keeping the surroundings clean and strong enforcement approaches. The research has recommended all the state highway agencies to maintain the track record of graffiti-related costs as a separate cost from other highway maintenance activities, by which, the magnitude of the problem can be determined and the removal and prevention measures may be implemented accordingly. The research has also identified a fact that the communication, cooperation and coordination among highway agencies and other agencies such as law enforcement agencies and citizen groups is more important in mitigating graffiti. High levels of law
enforcement activities and surveillance could be adopted in highly graffiti susceptible areas with the help of enforcement officials and police (Eck and Martinelli 1998).

1.2 Problem Statement

Currently, Nevada is one of the major states suffering from graffiti problem. It was estimated that graffiti damage costs in Southern Nevada was around $30 million a year. Particularly, graffiti vandalism on the highway infrastructures of Nevada has become an eyesore to the Nevada Department of Transportation (NDOT). The major highway structures that are suffering from graffiti in Nevada are bridges, sound walls, retaining walls and traffic signs. Removing graffiti from these infrastructures is a big challenge to the maintenance division of NDOT. ‘Paint over’ was the method adopted by NDOT to remove graffiti. NDOT has also tried using anti-graffiti coatings but these are proved to be labor intensive and less effective. At some places, as soon as the removal team removes graffiti, taggers are repeating the vandalism in the same places to represent their gang reputation. To avoid this repeating vandalism, NDOT is looking for permanent proactive countermeasures to prevent graffiti on highway infrastructure. The current problem is to develop anti-graffiti countermeasures to prevent graffiti on highway structures of Nevada.

1.3 Objectives

The objectives of the present study are (1) to identify a spectrum of graffiti countermeasures for highway structures of Nevada, and (2) to evaluate these countermeasures using cost-benefit analysis.
To identify a spectrum of graffiti countermeasures, literature review was conducted to collect the information on graffiti, graffiti removal and anti-graffiti activities that have been adopted in different jurisdictions such as cities, counties, and states. Addition to literature review, visits to selected cities and counties were made verifying the practices of anti-graffiti activities. A survey was also conducted to the states in the United States about the practices of preventing graffiti in state DOTs. Data on graffiti on the major highway facilities in the Las Vegas and Reno areas were collected from which the factors that might influence the occurrence of graffiti were identified. With these activities, promising graffiti countermeasures were identified. From each of the identified countermeasures, relevant cost and benefit data were collected and a cost and benefit study was conducted correspondingly.

1.4 Organization of the Thesis

The remaining thesis describes the work completed to meet the objectives of the research. Chapter 2 presents the literature review that was conducted in this study. In Chapter 3, the methodology taken in identifying a spectrum of countermeasures and cost and benefit analysis was discussed. Chapters 4, 5, and 6 present the survey results, the summary of the visits to cities, counties and DOTs, and detailed analysis of inventory data collected. In Chapter 7, the cost-benefit analysis of the countermeasures identified in the previous chapters is described. Chapter 8 presents the recommendations in this study for implementation.
CHAPTER 2

LITERATURE REVIEW

A literature review was conducted to identify some of the countermeasures to prevent graffiti on highway infrastructure. This chapter discusses the types of graffiti, structures affected by graffiti, graffiti removal and preventive techniques adopted in different states and countries, and the effectiveness of these techniques.

2.1 Types of Graffiti

Graffiti varies from a bare, utilitarian scrawl meant to convey a message to large attractive murals that take 20 to 30 cans of paint (Claire-King B, 2003). In general, there are five major types of graffiti: 1) Hip-hop graffiti, 2) Gang graffiti, 3) Conventional graffiti, 4) Ideological graffiti, and 5) Stenciling. These types of graffiti are presented in Figure 1.

- Hip-hop graffiti: Hip-hop graffiti is a cultural art that has different forms such as Tagging, Throw-ups and Pieces or Murals. Tagging is the most familiar type of hip-hop graffiti. It is a style of writing the names, signatures, nick names or some other words that represent the taggers. The size of this style of graffiti is relatively small when compared to other types of graffiti. Throws-up is the less common type of hip-hop graffiti, which contains large bubble style words. Pieces/Murals are complex paints that contain some forms of artistry. They are usually highly
colorful, more stylized and relatively large in size.

- **Gang graffiti:** The name itself describes that tagger gangs create gang graffiti. They make graffiti vandalism to convey threats of violence and the symbols they draw represent their gang and gang members.

- **Conventional graffiti:** This type of graffiti is to express the acts of malicious youthful exuberance.

- **Ideological graffiti:** It has different forms such as political and hatred graffiti, which are created to convey political messages, racial, ethnic, religious, or slurs.

- **Stenciling:** This type of graffiti is created by using different templates and is relatively very easy to create when compared to other types of graffiti. The templates are made of paper, cardboard or other media. The design that the taggers want to create, will be cut out of the media they selected and then spray paint would be transferred through this template, which is easy compared to other types of graffiti.
Figure 1. Types of Graffiti (Google Images, accessed in 2007)
2.2 Different Structures Affected by Graffiti

The structures affected by graffiti include bridges, sound walls, retaining walls, traffic signs, sign poles, railways, subways, buildings, parks and channels. This research is mainly concerned about the first four types of structures: bridges, sound walls, retaining walls and traffic signs, which are the major concern from the perspective of state department of transportation. Graffiti on these four structures is discussed below individually.

Bridges are the major highway structures that are affected by graffiti. Bridge piers, abutments, girders and beams are the main target areas for the taggers. Examples of the graffiti on these components of bridges are presented in Figure 2. These areas are afflicted with lots of words, patterns and pictures of artists made with tons of spray paint. Generally, taggers access to bridges through the piers and abutments to create graffiti. They regularly create graffiti on certain components like girders of the bridge even these places are hard to access. It is because graffitists want their handwork to be highly visible to the public.

Sound Walls are textured walls that are constructed along the highways to separate them from the nearby residential or commercial areas. The purpose of the sound walls is to absorb the sound from the highway traffic and reduce the noise impacts to the adjacent houses. There are different types of sound walls: concrete sound walls, brick sound walls, masonry sound walls, metal sound walls, and wood sound walls. The pictures in Figure 3 show different types of sound walls. Figure 4 presents graffiti on sound walls in the Las Vegas area.
Figure 2. Graffiti on Different Components of the Bridge
(Photos Taken by the Research Team in the Las Vegas Area in 2007)
Figure 3. Types of Sound Walls
Retaining Walls are also affected by graffiti to a large extent. Retaining walls can be easily accessible by the taggers than other components of the bridges. There are four types of retaining walls: gravity retaining walls, semi gravity retaining walls, cantilevered retaining walls and counter fort retaining walls. Figure 5 presents the graffiti on retaining walls in Las Vegas.
Traffic Signs are susceptible to public at all hours of the day and thus they were affected by graffiti. If the signs are attacked by taggers multiple number of times, then the signs have to be replaced. As the taggers mar the traffic signs by creating graffiti on them, people may not see and follow the traffic signs correctly, which causes a sort of inconvenience to the drivers and may result in accidents.

2.3 Graffiti Removal Techniques

In the literature, it was found that there are four major methods of removing graffiti: paint over, chemical removal, water-blasting and sand blasting. The usage of these methods varies according to the type of graffiti, type of surface, time factor and cost of removing. In the following sections, the graffiti removal methods, the paints and texture of the surface determining the graffiti methods, removal products, the typical methods to remove graffiti on the highway infrastructures, and the costs for removing graffiti are introduced.

2.3.1 Graffiti Removal Methods

Paint Over:

Painting over graffiti is found to be a more popular method of removing graffiti than using chemical solvents. If the portion of the area affected by graffiti is large, then painting over graffiti is the most economic method. If it is not possible to paint over the entire surface, then paint can be applied on graffiti in patches of rectangles. While painting over on graffiti, one has to make sure that the surface is clean and free from dust and other particles. In case of surfaces, where the base color is light and the graffiti color is dark, it is better to use a stain blocker first, which is a special kind of paint that
prevents the darker paint from penetrating into the surface. Generally, there are two types of paints that can be used in the paint over technique: (1) oil based and (2) latex paints. Latex paints are most economical and easier to clean than oil based paints. However, oil based paints are recommended in special cases, where the paint needs to be applied below freezing temperatures. It was also recommended in the literature to use the foam brushes to paint over the graffiti, as they are less expensive (City of Minneapolis, 1997).

In general, paint over method is economic in most of the cases. This it doesn't need heavy equipment like electric or diesel tools; and it is location friendly. But, this method is not suitable for unpainted surfaces because repeated paint over will not allow the surface to breath.

Chemical Removal:

Stubborn graffiti that cannot be removed by paint over method can be removed by chemical removal method. Biodegradable chemicals are preferred on metal or glazed surfaces, if the amount of graffiti is relatively small. There are different types of chemicals such as solvents containing hydrocarbons, solvents containing monoglycol ethers and glycol acetates, solvents containing polar solvents, solvents containing di-glycol ethers and solvents containing miscellaneous solvents, which can be used to remove graffiti (City of Las Cruces, 2007). Graffiti on traffic signs is usually removed by chemical removal method.

These chemicals are available in a variety of forms such as liquids, gels and creams. When using any chemical remover, the cleaners should follow the safety guidelines given by the manufacturer to avoid the adverse effects caused by this method
(City of Las Cruces, 1997). Although, chemical removal of graffiti is a fast, cost effective and relatively low labor removal method, it requires more saturation and dwell times and may need multiple applications.

Water-blasting (Mechanical Removal):

In water-blasting technique, graffiti is removed by using different washers such as pressure washers, power washers and jet washers. Manufacturer’s instructions and guidelines have to be followed, while using these washers. While using pressure washers, water alone or water together with a solvent can be used to remove graffiti from a surface. A solvent may first be applied and then the surface is washed with pressurized water. Sometimes a blasting media, such as baking soda, is used to remove graffiti (Graffiti Hurts, 2007). While removing graffiti from the surface using pressure washers, the surface may wear off, if the pressure ranges are higher than the required. The pressure ranges depend on the type of surface. Power washers with low pressures are suited for masonry structures such as brick, marble, stone, tile, concrete and granite, while as powerful jet washers with high pressures such as 3,150 psi are suited for any kind of surface. According to Graffiti Hurts (2007), the factors such as pressure rating, water flow rate, design of the spray nozzle, water temperature and the types of chemicals that were added to the stream are to be considered while deciding the type of washer. Generally, a normal pressure of (500-4000psi) will be used to clean graffiti. However, it varies from surface to surface. A low water pressure of below 100psi has to be used while removing graffiti from delicate masonry structure. A water flow rate of 4-8 gal/min is found to be efficient for removing graffiti. The nozzle having the spray fan angle of 15-50 degrees is preferred. Hot water is preferred to remove graffiti from the metal surface,
as the metal expands with the hot water, which may help in breaking the bond between graffiti and surface. The chemical additions that will be added to the water stream have to be diluted with water.

Water blasting is quick and economic for cleaning graffiti on big surfaces. However, repeated water blasting wears off the surface. Good drainage system is required for this technique and it is not effective in enclosed locations.

Sand Blasting (Mechanical Removal):

Sand blasting is an abrasive method, which is preferred on unpainted surfaces. If sand blasting technique is used to clean graffiti, the entire surface has to be sandblasted so that there will be no ‘ghost’ image of graffiti. This technique labor intensive, and requires much preparation and cleanup time. After sandblasting, the open pores of the surface are easily susceptible to deterioration. Proper safety precautions should be taken when using this technique to remove graffiti (City of Las Cruces, 1997).

2.3.2 Paints vs. Graffiti Removal

In order to better deal with graffiti problem, there is a need to know the properties of various paints and graffiti making tools that are discussed in this section. Graffiti vandals use variety of spray paints (polyurethanes, lacquers, and enamels), brush-applied paints (oils and synthetic resins such as vinyl, acrylics, acetates, methacrylates, or alkyds), water-soluble felt markers, ballpoint pens, chalk, graphite and colored pencils, pastels, wax and oil crayons, liquid shoe polish, and lipstick to make graffiti vandalism (Weaver, 1995).

Paints are composed of pigments, binders, and solvents. Pigments provide color and hiding power to the paint, binders hold the pigments together and to the substrate,
and solvents allow the pigment/binder mixture to flow (Weaver, 1995). Some spray paints and markers may contain dyes instead of pigments. The greater the solvent contents of the paint, the greater the flow rate, and thus, the greater the ability of the paint to penetrate into masonry pores (Weaver, 1995). The depth of penetration of paint into the masonry surface depends on various factors such as surface tension of the substrate and viscosity of the solvent. If the paint is penetrated well into the surface, then it is difficult to remove that penetrated paint, which leaves residual stains of graffiti.

2.3.3 Surface vs. Graffiti Removal

Removal techniques may vary with the surfaces affected by graffiti. According to City of Minneapolis (1997), some of the techniques given for different surfaces are as follows

Brick, Cement or Concrete surface:

Most of the NDOT sound walls and retaining walls have this type of surface. As far as the brick, cement or concrete surfaces are concerned, it is suggested to use extra strength paint remover. To enhance the effectiveness of the cleaning process, a wire brush may be used that can get into holes and pores of stone. An activation time of 10-15 minutes is to be allowed. After that the wall has to be rinsed from a forceful stream of water from any source of water. Then, the paint remover has to be applied to the surface using a pressure washer or soda-blower. For uniform surfaces that were flat, a light grit sand paper can be used to remove paint but this may damage the surfaces by scratching. After the removal, it would be better to use sealer to close pores and make future removal easier.
Painted Brick or Concrete:

Eggshells and oil paints are recommended to apply on these surfaces to make the surface smoother, which makes easy to clean graffiti from them in the future. Using zest of orange fluid was found to be successful on brick surface. Lots of water is needed to wash and rinse the brick or concrete surfaces. After the washing process, the surfaces will be refinished with the help of rubbing dirt into the brick with another brick.

Stucco:

Stucco has multi-faceted surface, so it is impossible use sand blasting technique. It was identified that paint remover has to be used following up by a high-pressure washers. After that stucco paint can be applied on the graffiti carefully. It was also suggested the usage of a sealer as a finish coat.

Wood:

If the graffiti on the wood surface is new, solvents can be used to clean it. On latex or oil-based paint, a stain-killing primer has to be used before applying paints. After this primer has dried, regular paints, oil or latex can be applied. Most of the oil-based paints are more durable to solvents and hence could help in making the future clean up easy. After the final finish, a sealer coat has to be used. It was suggested to avoid using flat paints as they readily absorb pigments from markers and spray paint. Specific paints such as Creosote and Wood Dye are useful, if graffiti is penetrated into the grain of the wood.

Fiberglass:

For this kind of surfaces, using paint thinner is suggested but, first, it has to be tested on an inconspicuous place to assure that it will not damage the surface.
Glass or Plexiglas:

On regular glass, any razor blade can be used to rub off the graffiti marks. For other big marks that cannot be removed by the blades, solvents can be used. Using the clean rag technique by holding the rag over the graffiti for a moment to let the solvent work is highly suggestible. On Plexiglas, it is better to avoid the lacquer thinner-type solvents as they can damage the surface causing it to fog and smear. It is always good to test whether the product is compatible with the type of the surface.

Metal:

Solvents can be used on any unpainted metal (iron or stainless steel) surface. If using solvents was unsuccessful, paint over method was suggested.

Painted metal:

For removing graffiti on painted metal, lacquer thinner has to be used to wipe out quickly. The solvent has to be selected depending on the nature of the metal surface. Otherwise, the surface may be subject to damage. Most of the traffic signs are having this type of surface.

Etching:

If the surfaces are scratched deeply or scored with notches, the surface has to be filled with fillers or has to be replaced. Body fillers can be used to fill these scratches. After filling with these fillers, they have to be repainted. If the fill up and replacing the glass, both are not possible, a fogged glass can be used to discourage future etching attacks by taggers. The other idea is etching over the vandal’s mark such as turning a “P” into a “B” and so on, to prevent the vandal visibility. It is a psychological sign to the vandals that the location will not tolerate the vandal’s message.
2.3.4 Removal Product

In market, various products are available that make graffiti removal easy. One of the famous products is SEI Graffiti Proofer Anti-Stick. It causes graffiti to run off protected surfaces and makes clean up easy as equivalent as washing windows (SEI Chemical, 2001). From the SEI Chemical website, it was observed that SEI Graffiti Proofer Anti-Stick provides high-slip characteristics that cause paint to crawl together and run off surface. So, it can be applied to variety of structures such as walls, buildings, bridges, vehicles, restroom partitions, and lockers. As per the manufacturer’s description, Graffiti Proofer Anti-Stick is a high-performance and extremely durable coating providing extremely high-slip characteristics. When a tagger tries to vandalize a structure protected with Anti-Stick, the paint will crawl together and run off the surface, deterring the vandal from continuing further. Unique chemistry makes the Graffiti Proofer Anti-Stick coating impervious to ultra-violet (UV) degradation, hydrocarbons, and a wide variety of chemicals, paints, inks, and dyes.

2.3.5 Graffiti Removal from Highway Structures

Graffiti removal from major highway structures bridges, sound walls, retaining walls and traffic signs are presented in this section.

Bridges:

One of the most effective methods of cleaning graffiti on surfaces of various bridge components is by the use of an abrasive blast cleaning system. Modern graffiti cleaning systems are wet (fully saturated) without any airborne dust (Ryall, 2001). However, there was no evidence for this from survey conducted. These systems are operated at very low pressures (typically 5-100 psi) so that cleaning is ‘gentle’ and will
not damage the bridge material. After the cleaning process, decorative and protective coatings such as UV cured acrylic copolymers can be applied for the enhanced appearance of the bridge.

Sound Walls and Retaining Walls:

From the field observations, it was found that most of the sound walls maintained in NDOT are of masonry and concrete structures. The common materials used in these structures are natural stones, manufactured clay materials, including brick and terra cotta; and cementations materials, such as cast stone, concrete and mortar (Weaver, 1995). These materials have the common properties such as porosity and sensitive to abrasion. The surface properties such as fragility, porosity and permeability, must be assessed to choose the type of removal technique. Graffiti on smooth and newly polished surfaces can be cleaned easily because these surfaces are relatively impermeable than rough surfaces. A very smooth, polished surface also has no pits or crevices that will retain particles of pigment or binder. In contrast, weathered marble or limestone may be extremely porous and permeable, with a rough surface on which particles of pigment can easily penetrate (Weaver, 1995). Removing graffiti on these surfaces depends up on the type of graffiti paint.

Traffic Signs:

Most of the graffiti that was created on traffic signs was "tagging". Chemical removal will be best suited for removing graffiti on traffic signs. In market, various chemical products are available. Tagster Graffiti Emulsifier is an example of such a product that encapsulates the affected area, and then re-liquefies and removes graffiti immediately (Vert Markets, Inc, 1996). This is a jell product and will not run off vertical
surfaces. It is biodegradable, non-toxic, non-caustic and non-flammable and comes in 16 oz. bottle and costs about $29.95. If it is not possible to remove graffiti on traffic signs, then it will be better to replace them.

2.3.6 Removal Costs

Removal of graffiti is becoming expensive. For many communities, private property owners, and public agencies, the removal costs are rising each year. Figures from a variety of cities across the U.S. suggest that graffiti cleanup alone costs taxpayers about $3-5 per person per year (Nograph Networks Inc, 2003). For smaller communities, the estimated annual graffiti removal costs are $1 per person or less. According to a survey of communities conducted by Public Technology, Inc. in 2002, Los Angeles County spends about $55 million per year on graffiti removal (population about 10 million), which has risen $20 million from 1998. Phoenix with a population of 1.3 million population and Minneapolis with a population of 382,000, each spend about $4 million. Santa Rosa, California with a population of 175,000 spends about $250,000 for graffiti removal. San Jose, with a population of fewer than one million, spends about $3 million per year to remove graffiti. In 1999, Sacramento County with a population of 1.2 million populations spent an amount of $500,000 on graffiti abatement. Pittsburgh, PA spent $500,000 in 2001. The annual graffiti costs in some other cities are: $350,000 in Baltimore; $2 million in Portland, OR; $1 million in Denver, and $250,000 in Madison, WI. The high removal costs show the significant importance of preventing graffiti from the society.
2.4 Graffiti Prevention Techniques

Various graffiti countermeasures that were found in the literature include: (1) Employ graffiti resistant surfaces, (2) Design modifications to control access, (3) Surveillance, (4) Rapid removal, (5) Keep the neighborhood clean, (6) Encourage citizen reporting, (7) Enforce anti-graffiti laws, (8) Initiating educational and awareness programs, (9) Retailer Education and sales bans, (10) Encouraging and facilitating legal graffiti, and (11) Graffiti tracker.

2.4.1 Employ Graffiti Resistant Surfaces

Anti-graffiti coatings can be applied to the surfaces in order to resist graffiti. They protect the substrate and make the removal of graffiti easy. These coatings are available in two types: sacrificial and non-sacrificial (permanent). Sacrificial anti-graffiti coating are designed to come off the surface during graffiti removal process (Graffiti Hot Line). High-pressure hot water can be used to remove graffiti on the surfaces that are treated with sacrificial anti-graffiti coatings. While removing graffiti, sacrificial coating also will be removed together with graffiti. Then the surface needs to be re-protected with two coats of sacrificial anti-graffiti coating (Paco Systems, 1997).

Non-sacrificial or permanent anti-graffiti coatings are usually water-based acrylic or solvent-based polyester urethanes. Water based coatings are less expensive and do not give any adverse effects, while as solvent based coatings are more expensive and give harmful vapors while applying, but last longer than water based coatings (Spiegelman, 1983). They are called permanent because graffiti can be removed with solvents or specialized biodegradable cleaners without harming the coating. They are to facilitate graffiti removal and stay in place after the removal process.
Anti-graffiti coatings are needed also for protecting porous surfaces such as brick, cement, and stone. When spray paint of graffiti is applied on these surfaces, it will be absorbed well deep below their surfaces. If the surfaces are not treated with anti-graffiti coatings, sandblasting technique may be needed to remove the stains of graffiti, which can damage the surface by making the surface more porous. As a result, water can penetrate deep into the material (Spiegelman, 1983). This penetrated water may freeze due to temperature changes and causes the surface cracks.

2.4.2 Design Modifications to Control Access

There were some design modifications found in the literature to control the access of taggers to the structures. These are discussed in the following sections.

Bridge:

Fencing on the top of the bridge was one of the measures found in the literature to prevent the access of taggers to bridge decks. Anti-graffiti panel to the girders of the bridge is one more preventive measure to control the access of taggers to the bridge girders. Figure 6 presents the fencing on the top of the bridge and anti-graffiti panel to the girders, which was outlined with red rectangle. In case of structural steel bridges, steel plates can be added to the bridge piers and abutments at the time of construction so that taggers cannot access to these structures.
For both reinforced concrete and steel bridges, chain link fencing can be arranged at the corners to deter the access of taggers to the outside girders. A chain link fence installed on the corners of the bridge was presented in Figure 7. Chain-link fencing should have its bottom edge secured with a tension wire or galvanized pipe, or should be seated in concrete to prevent easy lifting.
Sound Walls:

Ivy and vines can be planted along freeway shoulders to provide sound walls with a leaf cover, which was shown in Figure 8. But such vegetation requires an irrigation system, which is relatively expensive in Nevada. Also the ivy and vines take several years to completely cover a wall. It was recommended in the literature that planting bushes, thorny shrubs and other landscaping options would make it difficult for a vandal to have access to the surface of sound walls. But practically, these shrubs will not cover the entire sound walls. Moreover homeless people may go to the shadow coming
from the bushes and shrubs and live there. As they may not have any work to do, there is a big chance for them to turn as taggers.

![Ivy Planted on the Sound Wall on I-10 in California](Photo Taken by Research Team in 2008)

Chain link fencing can be arranged along all the way to sound walls. It can make the access of taggers to sound walls difficult. However the taggers may trespass to the sound walls by breaking the fencing and made graffiti. Anti-graffiti coatings can be applied to sound walls so that graffiti on these surfaces can be removed easily. It has been reflected by the NDOT maintenance crews that it would be hard to remove graffiti that is tagged on sound walls with coating.

Retaining Walls:

In a field visit that was made to the Flamingo Bridge on I-15, it was observed that the retaining walls under this bridge are highly affected by graffiti as there was no
fencing and taggers can have a free access to the retaining walls. Fencing is the obvious option to prevent graffiti on retaining walls. Anti-graffiti coatings can be applied to the retaining walls so that the graffiti on them can be removed easily without damaging the surface. But removing graffiti from the retaining walls with coatings applied also has the same problem as that for sound walls.

Traffic Signs:

To prevent graffiti on traffic signs, the popular countermeasure is design modification rather than coatings and fencings. To protect traffic signs, Caltrans has implemented four typical measures. One is called Rat Guard, which has been adopted in NDOT. The picture in Figure 9 is one made by the NDOT maintenance division. The cost of rat guards can be minimized if they are designed by in house maintenance division. Rat guards are attached to the sign poles to prevent the access of taggers to the overhead signs. These guards are made of 16-guage sheet metal that is too stiff to climb over and too flexible to stand on (NDOT, 2008). According to NDOT experience, rat guards are good in mitigating graffiti and it was found that 90% of the graffiti was mitigated on the signs, where rat guard was installed. Use of rat guards would save thousand of dollars for graffiti removal on signs.
The second measure is concertina wire or barbwire that can be wrapped around the column or end posts as a way of discouraging taggers from gaining access to the overhead signs. Such a concertina wire is shown in Figure 10. The third one is Graffiti Shields, which vary in length and width, extend over the front and sides of overhead signs, making it difficult for someone to reach over and deface the signs. Graffiti shields were also adopted by NDOT. From the NDOT experience, it was observed that 90% of graffiti was reduced on the signs where shields were installed. A picture for Graffiti Shields is provided in Figure 11.
Figure 10. Concertina Wire
(Picture Taken on I-10 in California by Research Team in 2008)

Figure 11. Graffiti Shields
(http://members.cox.net/mkpl/mtr2/mtr2-08_5-shoemaker.jpg)
The fourth measure is Nugard, which is another alternative to prevent the access of taggers to sign poles. A picture for Nugard was provided in Figure 12. It is a metal sleeve, which is wrapped around sign poles and is covered with jagged points. Anyone who tries to climb over the sharp points will come down.

![Figure 12: Nugards to Sign Poles](Picture Taken by Research Team on I-10 in California in 2008)

2.4.3 Surveillance

Surveillance camera is a commonly employed countermeasure to graffiti that can be installed in graffiti-prone sites. These cameras are connected to closed circuit televisions that are under real-time observations. This arrangement can make maintenance people catch taggers easily. However, to be more effective, the camera surveillance needs to be under full-time observation. Some times the taggers may damage
the cameras and then make graffiti on the nearby structures. So, some times fake cameras are installed making the taggers aware that there are some cameras in the area and the area is under surveillance. It was also revealed by some taggers that if taggers see a camera, they just wear their hoods and pull them down to hide their identity. This would make prosecution from videotape evidence very difficult, reducing the deterrence effect of the cameras (Wylie, 1999).

There are different functions for a surveillance camera. The camera could be infrared technology based to detect the tagger activities. The detection of tagger activities can trigger the operation of cameras to take pictures of the tagger activities. The pictures can be stored in a computer storage device for download in a certain time interval by maintenance personnel.

2.4.4 Rapid Removal

Rapid removal of graffiti is the most effective method to prevent future vandalism. This is frequently cited in the literature concerning graffiti because it nullifies the notoriety or “fame” sought by taggers and shows taggers that the site is being watched (Bentley, 1997). Rapid removal by paint over within 24 hours of a new tag appearing is widely suggested in the literature as the most effective response to graffiti vandalism, although the criticality of the 24 hour time period has been the subject of debate in recent times (Bensemman and Sutton, 1997). In case of private properties, it may not easy to get the permission from the owners to remove graffiti within 24. But in the case of public highway structures, this concept may work well as the DOTs of different states would take care of removal on their own properties. The City of Las Vegas is divided into 5 zones by the rapid response team. The team consists of five
members, and each member will take care of one zone. The team works on 24 hours based rapid removal of graffiti. From their experience, it was observed that rapid removal of graffiti was successful in mitigating graffiti in many places.

Research undertaken in Australia suggests that rapid removal is more effective when the policy covers both public and private property to avoid displacement, when all public agencies and service companies such as Telecom and power companies agree to adopt similar rapid removal policies, when assistance is provided to private property owners, such as provision of free removal services or paint-out kits, and when community groups and offenders on community service are involved in the implementation of the policy (Queensland Department of Justice, 1998)

2.4.5 Keep Neighborhood Clean

Graffiti attracts graffiti, cleanliness also attracts cleanliness, and when a site is clean, people are less inclined to mar it. One should make every effort to keep the appearance of a neighborhood clean and neat. Removing litter and trash, fixing the fences that were broken, trimming the landscape to a beautiful shape, checking the lighting are some measures to be taken to keep the neighborhood clean. According to the Los Angeles Police Department, an exterior appearance that suggests apathy and neglect attracts vandals.

2.4.6 Encourage Citizen Reporting

Encouraging citizen reporting of the graffiti cases will reduce the additional work of surveillance officials. In many cities, an 800 number, a dedicated telephone line, or a web site is established for this purpose. Prompt response to these reports will make reduce the graffiti in that area. In Western Australia, neighborhood support groups have
been supported in looking out for this type of offending, and are encouraged to report graffiti to the police (Bentley, 1997).

2.4.7 Enforce Anti-Graffiti Laws

Strong Law enforcement that was dedicated to tracking and apprehending graffiti vandals was found to be a strong deterrent of graffiti. The problem of illegal graffiti can be dealt with more effectively when it is clearly viewed as an offense and treated as a crime. Having police officers focused largely on the issue of graffiti gives them the time needed to really get to know who the offenders are and to successfully prosecute (Wylie, 1999). If the law enforcement officials work together with communities and courts, it would be easy to arrest the taggers. A survey of arrested taggers found "fear of getting caught" was the top response when asked what would get them to stop tagging (Graffiti Hurts, 2007). Increasing the penalties for those taggers who involved multiple times in tagging activities is one effective measure. If the taggers are children, parents of the taggers might be responsible.

According to Clark County Code, if the graffiti vandals were considered as a misdemeanor, the punishment will be a minimum $1,000 fine and up to 6 months in jail. If the vandalism was considered as felony, the taggers is subject to 4 years in prison, a $5,000 fine, drivers license revocation, unlimited restitution, and more than 200 hours of community service cleaning up graffiti.

2.4.8 Initiating Education and Awareness Programs

Preventive education is an important component of any successful graffiti vandalism prevention strategy. Education and awareness rising at many levels is important in countering graffiti, targeting children before they start tagging. Public
education, school based programs, and promotion of design concepts which reduce the likelihood of a property being tagged need to be promoted and undertaken to achieve lasting reduction in the graffiti problem. It was suggested by the maintenance officials that educational awareness to children should start right from the elementary school levels. Education aimed at recognizing graffiti as a crime, developing intolerance of any action against illegal graffiti, stopping young people from starting such activity, and preventing graffiti on one’s property or removing it soon after it occurs all helps reduce vandalism in the longer term (Wylie, 1999). Providing citizen volunteers with graffiti cleanup kits to keep an area they have "adopted" graffiti free is a good deterrent for graffiti. These programs improve awareness and engage citizens in graffiti prevention.

2.4.9 Retailer Education and Sales Bans

Retail store managers also can help in mitigating graffiti. They need to educate their staff about the legislation related to sale of spray paints to minors. Proper measures have to be taken to prevent the shoplifting of graffiti making tools. The person who is at checkout counter has to check the age proof of the person buying the spray paints.

2.4.10 Encouraging and Facilitating Legal Graffiti

Legal graffiti projects such as graffiti walls, murals, graffiti art exhibitions and courses on graffiti art can be facilitated so that illegal graffiti on public places can be controlled. These projects recognize and support the positive aspects of graffiti such as artistic talent. Graffiti murals reduce graffiti at mural sites, as the graffitists do not write on the graffiti created by other graffitists. So these projects will be effective in repeatedly targeted areas. However, encouraging legal graffiti has also its own disadvantages as some graffitists take this as an opportunity to improve their skills and implement them
illegally in other places. Many of the graffitists do not wish to involve in legal graffiti projects, as their main intention is to create vandalism illegally.

2.4.11 Graffiti Tracker

Graffiti Tracker is a program to analyze the graffiti made by taggers and finding the taggers, who made the graffiti. The graffiti pictures have to be uploaded to the software of the tracker program. It costs $1 for each picture to upload. The tracker program identifies the graffiti made by the same taggers and then it will mark the locations having same name of tag. Thus, it can locate the areas, where taggers live so that law enforcement officers can arrange extra surveillance in those areas.

From the above literature review, some promising countermeasures for highway structures are identified for evaluation.
CHAPTER 3

METHODOLOGY

To achieve the objectives of this study, a methodology was developed that consists of a two-step process. The first step is to identify a spectrum of countermeasures that are possible for preventing graffiti on highway infrastructure. This step includes conducting a survey to maintenance divisions of all state DOTs, visiting to cities, counties and DOTs for their practice to mitigate graffiti, and analyzing the inventory data collected on the freeway systems in the Las Vegas and Reno areas. The second step is to evaluate the countermeasures identified in the first step by conducting a cost-benefit analysis. These two steps are discussed in detail in the following sections.
3.1 Identifying a spectrum of countermeasures

A questionnaire was designed and distributed to 50 states. The questionnaire include groups of questions with focus was given to the graffiti prevention measures. These measures include those for touching and accessing of vandals to the highway structures, design policies, usage of security cameras for surveillance, mutual cooperation between the agencies such as state DOTs, local governments, communities and schools, types of educational activities to children to fight against graffiti, punishments and enforcement activities to taggers and criteria of punishment, and implementation of Crime Prevention Through Environmental Design. After the collection of the responses to the questionnaires, the responses were keyed in computer, which was then used to produce statistics of the answers.
First hand information about the practice of anti-graffiti was collected through visiting several cities, counties and DOTs: City of Los Angeles, City of Phoenix, City of Las Vegas, Clark County, Caltrans, ADOT, and NDOT. Although these cities don’t maintain highway systems, the way they treat graffiti vandalism and the removal techniques may be revealing to state DOTs. During the meetings, their graffiti policies, removal and preventive techniques that they are implementing, and their success stories were learnt. The visits provided valuable information about costs and benefits of the measures that they were adopting.

The inventory data of graffiti were collected for the Las Vegas and Reno areas in Nevada with the purpose of identifying factors that influence graffiti. The highway infrastructures for which graffiti data were collected primarily included bridges, sound wall, retaining walls, and traffic sign. The inventory data are the number, the type and the amount of graffiti on an infrastructure, the existence of fencing and accesses and the land use type and the quality of community around an infrastructure. Linear regression models were developed based on these data collected. The dependent variable is the amount of graffiti in square foot, and the independent variables include the roadways where an infrastructure is, the land use type, type of community, etc. The factors that were statistically significant were identified and then used in identifying the countermeasures for cost and benefit analysis.
3.2 Cost-Benefit Analysis

Cost and benefit analyses were conducted to several identified countermeasures: fencing, rat guard/shields, coating, security cameras, electronic spectrometers, and graffiti database. The first four countermeasures were analyzed quantitatively whereby the costs and benefits were calculated. The costs include capital, installation and maintenance costs. The capital and installation costs are one time costs while the maintenance costs incurred over the lifetime of these countermeasures. The maintenance costs over the lifetime were converted to the present value. The benefits, except for the coating, were primarily the saving of costs for graffiti removals with the adoption of the countermeasures. In the case of the countermeasure of coating, the benefits were more about the saving for restoring the properties to be damaged by graffiti. In the cost and benefit analysis, the factors existing in the application of the countermeasures that potentially stoke the balance between the costs and benefits were identified.

For the countermeasure electronic spectrometer, the costs were provided, but the benefits were provided in a qualitative manner. The impact of the patches of paint over without the application of electronic spectrometers was analyzed from the perspectives of visual and social effects. Such a qualitative based analysis can also make the balance between the cost and benefits obvious for decision-making by relevant officials.

In the case of electronic database, the usefulness of the database was presented. In addition, the ease of developing such a database was also addressed which is helpful to show the two sides of cost and benefits.
CHAPTER 4

SURVEY TO STATE DOTs

The survey consisting of 37 questions related to graffiti removal and prevention was sent to maintenance divisions of 50 state DOTs. A total of 31 responses from the state DOTs out of which, 4 from the different districts of Virginia and Florida were achieved. Out of these states, the response rate was around 62%, which shows that graffiti problem has significant concern in many states. Some states like Montana, Mississippi, Minnesota, Tennessee, South Carolina and Texas have no significant problem of graffiti on their highways. The results of the survey are presented in the following sections

4.1 Survey Results

4.1.1 Graffiti Removal

1. Do you have routine maintenance operations to remove graffiti, separating from other highway maintenance activities?

☐ Yes ☐ No

As the intensity of the graffiti problem varies from state to state, the removal activities also may vary accordingly. If the intensity of graffiti is more, a separate graffiti removal team dedicating only for graffiti may be in work. To know this fact, a question was prepared in the survey to know whether the respective DOTs have routine
maintenance operations to remove graffiti, separating from the highway maintenance activities. Out of the 31 responses, nine states have routine maintenance operations specifically to remove graffiti, separating from the highway maintenance activities. The remaining states are considering the graffiti removal activity as a part of their routine maintenance activities.

2. What kind of communication and information sharing should be required between the following divisions for graffiti removal and countermeasures?

Planning and maintenance: ________________________________
Design and maintenance: ________________________________
Construction and maintenance: ________________________________

To eradicate graffiti problem, it is desirable to take the measures in various steps: planning, design, construction and maintenance. There should be mutual communication among these four divisions to fight against graffiti. A question was prepared in the survey to know the type of communication and information sharing that should be required between Planning and Maintenance, Design and Maintenance and Construction and Maintenance about graffiti removal and prevention measures. Twelve responses are received for this question. Some of the states replied that Planning and Maintenance divisions share information about the cost issues, the location of structures that may be targets for graffiti, potential difficult spots, the amount of graffiti and the methods that work and budget issues. The replies about the communication between Design and Maintenance divisions include selecting the countermeasures, choice of materials used to clean up of graffiti, suggestions on design of countermeasures and about landscaping options. The information sharing between Construction and Maintenance include any coordination that was missed during design phase and the importance of adhering to the
plans and quality instruction. The replies to this question show that it would need a sequence of ideas to be implemented between planning, design, construction, and maintenance divisions to wipe out graffiti vandalism.

3. Rank the following graffiti removal techniques for each of the structures bridges, sound walls, retaining walls and traffic signs with 1 being the most cost-effective and 7 being the least cost-effective.

<table>
<thead>
<tr>
<th>Graffiti Removal Technique</th>
<th>Bridges</th>
<th>Sound Walls</th>
<th>Retaining Walls</th>
<th>Traffic Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-pressure water sprays</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repainting the surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandblasting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint remover: solvents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint remover: alkalis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating/resurface agents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graffiti removal techniques may vary from structure to structure. The effectiveness of these techniques may be more for some structures and less for other. To know the effectiveness of the techniques for bridges, sound walls, retaining walls and traffic signs, a question was prepared such that Rank one being the most effective technique and Rank seven being the least effective. The responses to this question show that for bridges – high pressure water sprays, for sound walls and retaining walls – repainting the surface, for traffic signs – paint remover: solvents are the most effective techniques.

4. What kind of instruments do you use to scan the colors for selecting the color that matches with the base color?

- [ ] No such instruments
- [ ] Electronic Spectrometers
- [ ] Color sensors
- [ ] Others (Please specify ___________________________________________)

45
While removing graffiti from a surface by paint over method, it would be desirable to use the paint that exactly matches with the base color of the surface so that the patches of repainting would be less visible. For choosing the matching color, color-matching instruments such as spectrometers and color sensors may be used. A question was prepared in the survey about the type of instruments the state DOTs would use for color matching. The responses for this question show that 25 states don’t use such instruments, two states use electronic spectrometers, three states have their home improvement store to match paint sample, and one state does the task by visual inspection.

5. What kind of graffiti abatement policies do you have?

- □ 24-hrs abatement policy  □ 48-hour abatement policy  □ 72-hour abatement policy  
- □ Others (Please specify__________________________________________)

The graffiti abatement policies vary from state to state. Some states may have 24-hour graffiti abatement policy, some may have 48-hour policy and some other may have 72- hour policy. However, these policies may depend on the severity of the problem in that particular state. A question was asked in the survey about the graffiti abatement policies the states had. Out of 31 replies, two states have 24-hr graffiti abatement policy, two states have 48-hr graffiti abatement policy, three have the policy of removing graffiti as soon as it was notified, one has the policy of removing graffiti as a part of bridge inspection, one has the policy of 24-hr on graffiti containing offensive messages and once/week on the remaining, three have the policy of removing immediately on graffiti with offensive messages and no policy on the remaining graffiti, no state has 72-hr abatement policy, and 19 have none of those abatement policies.
6. Which of the following ways are you using to receive graffiti reports?

- Telephone  
- Email  
- Both  
- Other (please specify __________________)

Encouraging citizen reports’ is one of the preventive measures identified in the literature. Citizens can report graffiti in progress or graffiti after its occurrence, to the concerned officials through different ways like telephones, emails, both of these and other ways. A question was prepared in the survey about the ways of receiving graffiti reports. The replies are: two states used telephone only, no state used email only, 17 used both telephone and emails, five states didn’t specify any graffiti report methods and seven states indicated different other ways of receiving graffiti, which include self observations of graffiti by the maintenance teams while checking routes and through websites.

7. In which way do you advertise the graffiti hotline number?

________________________________________________

A question was followed up about the several ways of advertising graffiti hot line number. Out of 31 responses, 23 states have no such ways of advertising. The other eight have different ways such as: through local municipalities, law enforcements, traffic management centers, banners & media events, websites, flyers, police, staff, highway help line and local agencies.

4.1.2 Graffiti Prevention

This section of the survey presents the questions related to graffiti prevention measures adopted by different states.

8. What are the specific colors of paints that can be applied on the surfaces so that graffiti on these colors may not stand out longer?

- No such colors  
- Brick red  
- Brown  
- Grey  
- Others (Please specify ______________________________________________________)

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It was indicated in the literature that graffiti on some colors of paints wouldn’t last longer. These colors may be applied to the surfaces having wide area, such as sound walls. A question was asked to identify the specific colors of paints that can be applied on the surfaces so that graffiti on these colors may not stand out longer. 20 states don’t have such specific colors. Six states were specified ‘grey’ color gave them good results. Only one state has chosen ‘brown’. The remaining states mentioned that they would use some neutral colors or dark colors and mostly the color varies by shades.

9. What are the major textures for the following highway infrastructures?

- Bridges: Piers
- Girders
- Abutments
- Beams
- Sound walls
- Retaining walls
- Traffic signs

However, the type of paint that could be used to the surfaces depends on the surface texture also. The surface textures vary from structure to structure. A question was asked in the survey to know the types of major textures for different highway structures. Out of the 18 responses for this question, which are listed in Table 1, the replies vary a lot and most of them mentioned smooth and rough concrete for bridges, finished brick and concrete for sound walls, surface finished smooth concrete for retaining walls and smooth metal sheets for traffic signs.
Table 1: Infrastructure Textures

<table>
<thead>
<tr>
<th>State</th>
<th>Piers</th>
<th>Girders</th>
<th>Abutment</th>
<th>Beams</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>Smooth/ Sometimes roughened architecturally</td>
<td>Smooth</td>
<td>Smooth/ Sometimes roughened architecturally</td>
<td>Smooth</td>
</tr>
<tr>
<td>NC</td>
<td>Timber, steel, concrete</td>
<td>Steel, Concrete</td>
<td>Concrete</td>
<td>Steel, Concrete</td>
</tr>
<tr>
<td>Penn DOT</td>
<td>Finished concrete</td>
<td>Finished concrete/painted steel</td>
<td>Finished concrete</td>
<td>Painted steel</td>
</tr>
<tr>
<td>WA</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Smooth, Fracture fin</td>
<td>Smooth</td>
</tr>
<tr>
<td>Idaho</td>
<td>Concrete, steel</td>
<td>Concrete, weathered steel</td>
<td>Concrete</td>
<td>Concrete, weathered steel</td>
</tr>
<tr>
<td>WV</td>
<td>Rough</td>
<td>Smooth</td>
<td>Rough</td>
<td>Smooth &amp; Rough</td>
</tr>
<tr>
<td>Utah</td>
<td>Steel form concrete</td>
<td>Painted steel &amp; smooth precast concrete</td>
<td>Formed concrete</td>
<td>Painted steel &amp; smooth precast concrete</td>
</tr>
<tr>
<td>VA-S</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Smooth</td>
</tr>
<tr>
<td>VA-N</td>
<td>Concrete</td>
<td>Steel</td>
<td>Concrete</td>
<td>Steel</td>
</tr>
<tr>
<td>VA-C</td>
<td>Concrete</td>
<td>Steel</td>
<td>Concrete</td>
<td>Steel/Concrete</td>
</tr>
<tr>
<td>NM</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Smooth</td>
</tr>
<tr>
<td>MD</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>ND</td>
<td>surface finished (Textured concrete)</td>
<td>Surface finished (Textured concrete)</td>
<td>surface finished (Textured concrete)</td>
<td>surface finished (Textured concrete)</td>
</tr>
<tr>
<td>MI</td>
<td>Plain Concrete</td>
<td>Plain Concrete</td>
<td>Plain Concrete</td>
<td>Plain Concrete</td>
</tr>
<tr>
<td>VDOT</td>
<td>Smooth finished concrete</td>
<td>Smooth painted surface (steel)</td>
<td>Smooth/ Grooved</td>
<td>Smooth painted surface (steel)</td>
</tr>
<tr>
<td>AZ</td>
<td>Smooth concrete</td>
<td>Smooth concrete</td>
<td>Smooth concrete</td>
<td>Smooth concrete</td>
</tr>
<tr>
<td>Iowa</td>
<td>Smooth concrete, Trowled finish</td>
<td>Smooth concrete, Trowled finish</td>
<td>Smooth concrete, Trowled finish</td>
<td>Smooth concrete, Trowled finish</td>
</tr>
<tr>
<td>FL</td>
<td>class V finish</td>
<td>Fascia girders class V finish</td>
<td>class V finish</td>
<td>Fascia girders class V finish</td>
</tr>
</tbody>
</table>
Table 1: Infrastructure Textures (cont.)

<table>
<thead>
<tr>
<th>State</th>
<th>Sound Wall</th>
<th>Retaining Wall</th>
<th>Traffic Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>N/A</td>
<td>Smooth/Sometimes roughened architecturally</td>
<td>Smooth</td>
</tr>
<tr>
<td>NC</td>
<td>Brick, Concrete panels</td>
<td>Timber</td>
<td>Smooth</td>
</tr>
<tr>
<td>PennDOT</td>
<td>textured concrete</td>
<td>finished or textured concrete</td>
<td>NA</td>
</tr>
<tr>
<td>WA</td>
<td>Fracture fin</td>
<td>Smooth, Fracture fin</td>
<td>NA</td>
</tr>
<tr>
<td>Idaho</td>
<td>fluted Concrete, wood</td>
<td>fluted Concrete, wood</td>
<td>aluminum, plywood</td>
</tr>
<tr>
<td>WV</td>
<td>Rough</td>
<td>Rough</td>
<td>Smooth</td>
</tr>
<tr>
<td>Utah</td>
<td>exposed aggregate, cast decorative and fluted panels</td>
<td>fluted precast concrete, smooth steel form finish</td>
<td>3-M type IX sheeting</td>
</tr>
<tr>
<td>VA-S</td>
<td>Rough</td>
<td>Smooth</td>
<td>Smooth</td>
</tr>
<tr>
<td>VA-N</td>
<td>Concrete</td>
<td>Concrete</td>
<td>Metal</td>
</tr>
<tr>
<td>VA-C</td>
<td>Steel/Concrete / Wood</td>
<td>Concrete</td>
<td>Reflective Point</td>
</tr>
<tr>
<td>NM</td>
<td>Exposed Aggregate</td>
<td>Smooth/Exposed Aggregate</td>
<td>Smooth</td>
</tr>
<tr>
<td>MD</td>
<td>Noise Dampening Material</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>ND</td>
<td>surface finished (Textured concrete)</td>
<td>surface finished (Textured concrete)</td>
<td>N/A</td>
</tr>
<tr>
<td>MI</td>
<td>Plain Concrete</td>
<td>Plain Concrete</td>
<td>N/A</td>
</tr>
<tr>
<td>VDOT</td>
<td>Concrete fiber/ corrugated metal</td>
<td>Finished smooth concrete</td>
<td>Smooth finish (aluminum)</td>
</tr>
<tr>
<td>AZ</td>
<td>Block or stucco</td>
<td>concrete</td>
<td>smooth reflective material</td>
</tr>
<tr>
<td>Iowa</td>
<td>Smooth concrete, Trowled finish</td>
<td>Smooth concrete, Trowled finish</td>
<td>Sign sheeting</td>
</tr>
<tr>
<td>FL</td>
<td>form finish</td>
<td>form finish</td>
<td>N/A</td>
</tr>
</tbody>
</table>
10. What are the different anti-graffiti coatings you are applying for?

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Sacrificial (If yes, give products)</th>
<th>Non-Sacrificial (If yes, give products)</th>
<th>Others (Specify the products)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abutments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound Walls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retaining Walls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Signs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Anti-graffiti coatings can be applied for the surfaces in order to resist graffiti and make the removal process easy. There are two types of anti-graffiti coatings found in the literature: Sacrificial anti-graffiti coatings and Non-Sacrificial anti-graffiti coatings. These coatings will protect the substrate and make the removal of graffiti easy. A question was included in the survey about various anti-graffiti coatings that can be applied to bridges, sound walls and retaining walls to resist graffiti. Most of the states have no specific anti-graffiti coatings for these structures. Four states, Rhode Island, Idaho, Michigan and Florida have answered this question. All these states mentioned Non-sacrificial anti-graffiti coatings for bridges, sound walls and retaining walls. These states have mentioned some product names. Rhode Island uses rain guard and blok guard (non-sacrificial anti-graffiti coatings) for bridge piers, abutments and for retaining walls. They don’t apply anti-graffiti coatings to the traffic signs. Idaho uses aliphatic polyurethane (non-sacrificial anti-graffiti product) for all the structures except traffic signs.
11. Do you have any countermeasures to prevent touching the structures such as?

**Bridges**  □ Unique anti-graffiti panel on the girder of bridges (See cover page)
□ Others (please specify) ________________________________

**Sound Walls**  □ Putting trellis to climb plants on walls
□ Others (please specify) ________________________________

**Retaining Walls**  □ Putting trellis to climb plants on walls
□ Others (please specify) ________________________________

**Traffic Signs**  □ Please specify ____________________________________________

Graffiti on highway structures may be prevented by deterring the touching of the structures by installing some measures such as anti-graffiti panels to the bridges, trellis to the sound walls and retaining walls. A question was asked to know the usage of these measures. Four states have responded for this question. Out of these four states, two has preferred installing anti-graffiti panels to the bridges, one has preferred putting trellis to sound walls, and one has preferred putting trellis to retaining walls.

12. Do you have any countermeasures to prevent taggers accessing to structures such as?

**Bridges**  □ Arranging chain link fencing at the top and corners of bridges
□ Others (please specify ________________________________)

**Sound Walls**  □ Planting thorny shrubs
□ Limiting access to roofs by moving dumpsters away from walls
□ Landscaping options
□ Arranging fencing
□ Others (please specify ________________________________)

**Retaining Walls**  □ Planting thorny shrubs
□ Limiting access to roofs by moving dumpsters away from walls
□ Landscaping options
□ Arranging fencing
□ Others (please specify ________________________________)

**Traffic Signs**  □ Rat guards
□ Concertina wire
□ Cobra shields
□ Metal collars (on the posts of the sign structures)
Preventing the access of taggers to the structures can also mitigate graffiti. These preventive measures vary a lot from structure to structure. Some of the preventive measures include arranging chain link fence to the bridges, planting thorny shrubs and other landscaping options to the sound walls and retaining walls, arranging fencing to the corners of the sound walls and retaining walls, installing graffiti barriers such as rat guards, concertina wire, cobra shields and metal collars to the traffic signs. A question was asked in the survey about the countermeasures to prevent the access of taggers to the structures. Out of the 31 states responded to the survey, 12 states have mentioned 'arranging chain link fencing at the top and corners of the bridges would prevent the access of taggers to the bridges. Three states have mentioned that fencing would also work for sound walls and retaining walls. Four states have mentioned that landscaping options would prevent access of taggers to the sound walls and retaining walls. No states has mentioned about the preventive measures for traffic signs.

13. Do you have any differentiation between reinforced concrete bridges and steel bridges in arranging fencing to deter the access of taggers?

□ Yes □ No
If yes, please specify ____________________________

While arranging fencing to the bridges to prevent the access of taggers, there might be differentiation between reinforced steel bridges and concrete bridges. A question was asked about this differentiation. One state Utah has responded this question. It has mentioned that the differentiation is in using crawl guards, collars and steel fillet in flange but it didn’t mention, how the usage is differentiated. Apparently most of railroad bridges are steel and was owned by private agencies. The requirements for anti-graffiti on the bridges owned by state DOT may not apply to these railroad bridges. In the case of
Las Vegas, there are steel bridges that have beams with large cross sections facing traffic, which may have provided spaces for tagging. The graffiti on these railroad bridges was usually large and frequent recurred. Removing the graffiti on these bridges involves cooperation of multiple agencies such as railroad companies and highway agencies, and traffic disruption for safety concern while removing the graffiti.

14. Do you have any sign shop manufacturing graffiti protection for existing sign structures?
□ Yes □ No

Another question was followed up inquiring whether the states have any sign shop manufacturing graffiti protection for existing sign structures. It was indicated in NDOT that their sign shop provided such service. The responses showed that no states have this kind of arrangement.

15. Do you have any design policy that sign structures must be located at least ten feet from any bridge or wall structure?
□ Yes □ No

As mentioned earlier, some design modifications of the structures may mitigate graffiti. A question was followed up regarding the design policies, whether they have any policy such as the structures must be located at 10 ft from any bridge or wall structure. Only Georgia State has this kind of policy. No other states are aware of such policies. This shows that there would be a need of thinking of design policies to prevent graffiti.

16. Did you grant permissions to other agencies (city, county, private firms) to clean graffiti on sound walls on your DOT Right of Way?
□ Yes □ No

As graffiti is a common problem, several agencies are also involved fighting against graffiti. Graffiti removal process may be easy, if all these agencies work together.
However, to clean graffiti from the highway structures, other agencies need permission from state DOT. A question was asked in the survey whether the state DOT grant permissions to the other agencies such as city, county and private firms to clean graffiti on sound walls on their DOT right of way. Out of the 31 responses for this question, eight state DOTs give permission to other agencies.

17. Do you use security cameras on graffiti-prone sites?

☐ Yes ☐ No

18. What are the issues that are to be considered in the process of installing security cameras?

☐ Reliability ☐ Cost ☐ Vandalism
☐ Others (please specify ________________________________________________)

Surveillance is one of the preventive measures found in the literature. The surveillance may be natural surveillance by people and police and the surveillance by security cameras. The cameras can capture the tagging and give voice signals to the taggers that the area is in monitor. This could make the taggers drop tagging. To know about the usage of cameras, a question was mentioned in the survey whether any state DOTs use security cameras on graffiti-prone sites. Out of the 31 responses, it was observed that three states Illinois, Michigan and New Mexico use security cameras on graffiti-prone sites.

There might be variety of issues such as reliability, cost and vandalism that are to be considered in the process of installing security cameras. The next question in the survey followed up on this issue. Out of the 31 responses for this question, the responses are listed in Table 2. It can be observed from the table that the highest responded issue was cost, which was followed by vandalism and reliability.
Table 2: Issues in installing security cameras for graffiti problem

<table>
<thead>
<tr>
<th>Issue</th>
<th>Number of Responses</th>
<th>Percentage of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>4</td>
<td>12.9</td>
</tr>
<tr>
<td>Cost</td>
<td>12</td>
<td>38.7</td>
</tr>
<tr>
<td>Vandalism</td>
<td>5</td>
<td>16.1</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>N/A</td>
<td>14</td>
<td>45.2</td>
</tr>
</tbody>
</table>

19. Do you plan to add lighting to promote natural surveillance?

☐ Yes ☐ No

One more idea to promote natural surveillance is to add lighting. One question about lighting was asked in the survey. Only Utah State indicated that they had a plan to add lighting for enhance natural surveillance. It has been notices that there might be some issues related to lighting. One is about the homeless persons to use the areas that are lightened up.

20. Do you have any civilian volunteer patrol groups, which call highway patrol groups and give witness to them when there is a “tagging” in progress?

☐ Yes ☐ No

Highway patrolling is primarily for law enforcement, not specifically for graffiti. Some volunteer patrolling teams may help the highway patrolling groups to notify tagging. A question was asked in the survey: whether the state DOTs have any volunteer patrol groups, which call highway patrol groups and give witness to them when there is a “tagging” in progress. Out of the 31 responses, the states of Washington and California indicate that they had this kind of volunteer patrol groups.
21. Do the local schools in your state have any cooperative relation with your DOT in getting rid of graffiti?

□ Yes □ No

22. Rank the effectiveness of following educational activities against graffiti with 1 as the most effective and 5 as the least effective for different levels of school.

<table>
<thead>
<tr>
<th>Activities</th>
<th>High schools</th>
<th>Junior high schools</th>
<th>Elementary schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing a course about anti-graffiti in their curriculum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making trips to fields showing graffiti vandalism and its disadvantages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conducting seminars on anti-graffiti and inspiring students to join in anti-graffiti unions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conducting dramas (mini-films) against graffiti</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (please specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Several questions were followed up regarding the cooperative relations between DOT and other organizations like schools, neighborhood community associations in preventing graffiti on highway structures. The responses to the questions on the cooperation between schools and DOTs indicate that only state Iowa has its local schools that joined with DOT to work against graffiti.

The role of schools against graffiti would be in terms of educating children to fight against graffiti. Teachers may bring awareness among students by letting them know the disadvantages and adverse affects of the graffiti vandalism. However, these educational activities may vary in different levels of schools. A question was included in the survey about the effectiveness of various activities to high schools, junior high schools and elementary schools. The replies for this question were required to be in
ranking to the activities, marking one as the most effective and five as the least effective.

The responses are listed in Table 3.

Table 3: Activities in high schools, junior high schools, elementary schools against graffiti

<table>
<thead>
<tr>
<th>Activities</th>
<th>High schools Rank</th>
<th>Junior high schools Rank</th>
<th>Elementary schools Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing a course about anti-graffiti in their curriculum</td>
<td>3.63</td>
<td>3.1</td>
<td>2.75</td>
</tr>
<tr>
<td>Making trips to fields showing graffiti vandalism and its disadvantages</td>
<td>2</td>
<td>3.4</td>
<td>2.50</td>
</tr>
<tr>
<td>Conducting seminars on anti-graffiti and inspiring students to join in anti-graffiti unions</td>
<td>2</td>
<td>3.4</td>
<td>2.71</td>
</tr>
<tr>
<td>Conducting dramas (mini-films) against graffiti</td>
<td>1.63</td>
<td>3.5</td>
<td>2.43</td>
</tr>
</tbody>
</table>

It can be found from the table that making trips to fields to show graffiti vandalism and its disadvantages is chosen to be most effective technique. Introduction a course about anti-graffiti in their curriculum was preferred for high schools. There was no activity outstanding for junior high and elementary schools.

23. How does your state DOT get help from neighborhood community associations in preventing graffiti on highway infrastructures?

- □ Having meetings with their community associations against graffiti
- □ Disseminating anti-graffiti information bulletin (contains anti-graffiti hot lines and website information) to their associations
- □ Encouraging graffiti reports from their communities
- □ Jointly organizing mural projects
- □ Others (please specify ___________________________)

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24. How does your DOT get help from police in preventing graffiti on highway infrastructures?

- Providing police with data regarding tagger gangs
- Police keep eye also on the areas beyond the roads (surveillance)
- Helping police conduct counseling programs to taggers to get change in their attitude
- Others (please specify ________________________________)

25. How does your state DOT get help from local government agencies (city, county, etc.) to fight against graffiti on highway infrastructures?

- Having meetings with anti-graffiti coalition regularly
- Exchanging ideas and information about graffiti
- Jointly organizing mural projects
- Others (please specify ________________________________)

Three more questions were followed up in the survey inquiring about the type of cooperation and help, DOT gets from neighborhood community associations, police and local government agencies in preventing graffiti on highway structures. The response data are listed in Tables 4, 5 and 6. Out of the 31 responses for these questions, most of the DOTs have no relations with neighborhood community associations, police and local government agencies in preventing graffiti. There were a few states mentioned that the help they get from neighborhood communities would be in terms of encouraging graffiti reports from their communities, from police would be in terms of surveillance of highways and from local government agencies would be in terms of exchanging data and ideas to fight against graffiti.
Table 4: Cooperation between DOT and neighborhood community

<table>
<thead>
<tr>
<th>Type of activity</th>
<th># of replies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having meetings with their community associations against graffiti</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Disseminating anti-graffiti information bulletin to their associations</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td>Encouraging graffiti reports from their communities</td>
<td>5</td>
<td>16.1%</td>
</tr>
<tr>
<td>Jointly organizing mural projects</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>None</td>
<td>25</td>
<td>80.7%</td>
</tr>
</tbody>
</table>

Table 5: Cooperation between DOT and Police

<table>
<thead>
<tr>
<th>Type</th>
<th># of replies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing police with data regarding tagger gangs</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td>Police keeps eyes also on the areas beyond the roads (Surveillance)</td>
<td>7</td>
<td>22.6%</td>
</tr>
<tr>
<td>Helping police conduct counseling programs to taggers to get change in their attitude</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Others: When needed, police reports, surveillance in graffiti-prone places</td>
<td>3</td>
<td>9.7%</td>
</tr>
</tbody>
</table>

Table 6: Cooperation between DOT and local government agencies

<table>
<thead>
<tr>
<th>Type</th>
<th># of replies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having meetings with anti-graffiti coalition regularly</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Exchanging ideas and information about graffiti</td>
<td>4</td>
<td>12.9%</td>
</tr>
<tr>
<td>Jointly organizing mural projects</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td>Others: City task force in providence, Youth service in repainting</td>
<td>2</td>
<td>6.5%</td>
</tr>
<tr>
<td>N/A</td>
<td>24</td>
<td>77.4%</td>
</tr>
</tbody>
</table>
26. What are the different options of punishing taggers in your state?

- Putting them in jails (range of jail period ________________)
- Charging fines (range of penalties/fines ________________)
- Making them involved in community service (No. of hrs/days of service ____)
- Others (please specify _________________________________)

Strong law enforcement by giving severe punishments to the taggers could mitigate graffiti. For a question asked about the several ways of punishing taggers, the replies are provided in Table 7. Note that some of the states have multiple answers.

Table 7: Punishing Taggers

<table>
<thead>
<tr>
<th>Type</th>
<th># of replies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putting them in jails (Range of jail period)</td>
<td>3</td>
<td>9.7%</td>
</tr>
<tr>
<td>Charging fines (Range of penalties/fines)</td>
<td>12</td>
<td>38.7%</td>
</tr>
<tr>
<td>Making them involved in community service (No. of hrs/day)</td>
<td>9</td>
<td>29%</td>
</tr>
<tr>
<td>Others: legal, cover cost of removal, report to police dept, remove graffiti</td>
<td>4</td>
<td>12.9%</td>
</tr>
<tr>
<td>N/A</td>
<td>13</td>
<td>41.9%</td>
</tr>
</tbody>
</table>

Most of the states have mentioned that charging fines and making taggers involved in community service are the effective ways of punishing taggers. No state has mentioned the range of punishments. It will be up to the judge. From interviewing cities like the City of Los Angeles, it was indicated that covering cost of removal has been popular and a good way to fund anti-graffiti programs.
27. On what criteria, taggers will be punished in jails?

- The amount of graffiti they made. If chosen, specify the amount _______
- Frequency of recurrence of graffiti vandalism. If chosen, specify the frequency ______
- Age of taggers. If chosen, specify the age ________________________________
- Others (please specify __________________________________________________)

28. On what criteria, taggers will be punished by charging fines/penalties?

- The amount of graffiti they made. If chosen, specify the amount _______
- Frequency of recurrence of graffiti vandalism. If chosen, specify the frequency ______
- Age of taggers. If chosen, specify the age ________________________________
- Others (please specify _________________________________________________)

29. On what criteria, taggers will be punished to involve in community service?

- The amount of graffiti they made. If chosen, specify the amount _______
- Frequency of recurrence of graffiti vandalism. If chosen, specify the frequency ______
- Age of taggers. If chosen, specify the age ________________________________
- Others (please specify __________________________________________________)

It is realized that punishing taggers will depend on several factors such as the amount of graffiti and property damage by tagger, the repentance of the vandalism by taggers and local jurisdictions. Three questions were followed up to know the criteria of punishing taggers in different ways. The responses are presented in Table 8. The results indicate that “amount of graffiti they made”, “frequency of recurrence of graffiti vandalism” were the popular criteria. Age is the least popular measure.
Table 8: Criteria to punish taggers

<table>
<thead>
<tr>
<th>Type of Criteria</th>
<th>Punishment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jails</td>
</tr>
<tr>
<td>Amount of graffiti they made</td>
<td>3</td>
</tr>
<tr>
<td>Frequency of recurrence of graffiti vandalism</td>
<td>3</td>
</tr>
<tr>
<td>Age of taggers (Age-18: only 1 state specified)</td>
<td>2</td>
</tr>
<tr>
<td>Others: All the above(1), Depends on Local jurisdictions (3)</td>
<td>4</td>
</tr>
<tr>
<td>N/A</td>
<td>22</td>
</tr>
</tbody>
</table>

30. Do you have any taxes on graffiti making tools in your state?

□ Yes □ No

One way of preventing graffiti is deterring the access of taggers to graffiti making tools. This could be done with the help of paint shop owners to set up a separate section for graffiti making tools in their store and see the IDs when selling these tools. One more way is to increase the taxes on graffiti making tools. For a question asked about the increase of taxes on graffiti making tools, it was observed that only the state of Virginia has this kind of taxes.

31. In what way, graffiti vandalism can be considered from your agency prospective?

□ Felony □ Misdemeanor

The states were also inquired, how graffiti vandalism can be considered from agency prospective. Almost all the states have mentioned graffiti vandalism as a ‘Misdemeanor’. Arizona mentioned it as a ‘Felony’.
32. Are you practicing the CPTED (Crime Prevention Through Environmental Design) Concept for graffiti prevention? (CPTED includes strategies like natural surveillance and access control etc).

□ Yes □ No

Preventing graffiti through practicing the Crime Prevention Through Environmental Design (CPTED) was in use in some countries like Australia, where as CPTED includes strategies like natural surveillance and access control. For a question asked about CPTED, the results indicate that California and Arizona are using CPTED technique to prevent graffiti on highways.

33. Do you think that aesthetic enhancement of structures can mitigate graffiti vandalism?

□ Yes □ No

A question was followed up about the impact of aesthetical enhancement of the structures in mitigating graffiti. Out of the 31 replies 9 states have mentioned that aesthetic enhancement of structures can mitigate graffiti vandalism.

34. What is the annual graffiti control expenditure for your state in the following years?

2005 ___________ 2006 ___________ 2007 ___________

A question was included in the survey to know the states annual graffiti control budget. Eight states answered this question. The replies are shown in Table 9. The amounts of expenditures over the years show different trends. In Utah and Arizona, the expenditure on graffiti has been increasing. The increased efforts may not be the direct results of work in previous years. The populations in these two states have been increasing for which the amount of graffiti may be increasing correspondingly. In states such as North Carolina, Maryland and New Mexico, less money has been spent on anti-
graffiti, which could be the results of either their efforts in previous years or the budget cut.

Table 9: Expenditure on Anti-graffiti

<table>
<thead>
<tr>
<th>State</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>N/A</td>
<td>N/A</td>
<td>$48,000</td>
</tr>
<tr>
<td>Utah</td>
<td>$54,423</td>
<td>$60,210</td>
<td>$84,171</td>
</tr>
<tr>
<td>Idaho</td>
<td>Small</td>
<td>Small</td>
<td>Small</td>
</tr>
<tr>
<td>Arizona</td>
<td>$100,000</td>
<td>$106,000</td>
<td>$120,000</td>
</tr>
<tr>
<td>ND</td>
<td>$5,000</td>
<td>$10,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>MD</td>
<td>$83,381</td>
<td>$127,235</td>
<td>$111,555</td>
</tr>
<tr>
<td>NM</td>
<td>$3,404.80</td>
<td>$1,221</td>
<td>$1,261</td>
</tr>
<tr>
<td>WV</td>
<td>Very little</td>
<td>Very little</td>
<td>Very little</td>
</tr>
</tbody>
</table>

35. Do you collect data regarding when and where graffiti occur on a daily basis?

☐ Yes      ☐ No

36. Do you store the data you collected in computer and use them for scheduling and routing for graffiti removal?

☐ Yes      ☐ No

Questions were followed to know about the data collection of graffiti and its utilization. The survey results show that four states collected data regarding when and where graffiti occur on a daily basis and three states store the data collected in computer and use them for scheduling and routing for graffiti removal.
37. Do you have any written materials on graffiti countermeasures for highway infrastructures?

□ Yes  □ No

To collect materials on graffiti for this study, a question was asked about the relevant written materials that available in the states. It was indicated that Virginia (Nova District) and California have some written materials on graffiti countermeasures for highway infrastructures.

4.2 Observations from the Survey

From the result analysis, the following observations can be concluded.

Specifying colors for the surfaces of highway infrastructures was not popular among the surveyed states. Most of states responded to the survey did not consider coating. The few provided their surveys indicated that it was the non-sacrificial anti-graffiti coatings that were considered. All the states chose not to apply coatings to traffic signs.

To prevent taggers from touching highway infrastructures, most of states didn’t have any measures in place. The promising countermeasures used in a few states are installing anti-graffiti panel on the girder of bridges, putting trellis to climb plants on sound walls and retaining walls.

Comparatively, there were much more states (about one third) installing countermeasure for accessing highway infrastructures which include chain link fencing at the top and corners of the bridge. A few states used fencing and landscaping options for sound walls and retaining walls. Even though in the literature, there were rat guards,
concertina wire, graffiti shields that were installed for traffic signs for preventing access, no states in the responded survey indicated that these countermeasures were installed.

In considering graffiti prevention, the reinforced concrete and steel bridges were not viewed differently. In other words, the countermeasures for reinforced concrete bridges can be installed the same way as for the steel bridges. No state used their own sign shops to manufacture countermeasures for traffic signs.

Even though the design policy such as the structures must be located at 10 ft from any bridge or wall structure, it was adopted in only one state. There were some states granting permissions to the other agencies to clean graffiti on their DOT right of way, which implies that there were other states that did not grant such permission. There were just a few states using security cameras for graffiti prevention. It can be perceived from the survey that cost, vandalism and reliability were really issues that preventing some states from adopting such a technology.

Adding lighting seems to be a countermeasure to promote natural surveillance. However, only one state was positive for it. Having volunteer patrol groups involved were adopted in only two states. If possible, it may be proven to be a viable solution.

In general, the cooperative relations between state DOTs and local school were not strong for the surveyed states. It may be reasonable because other local agencies like cities or county may being taking a leading role on this part. There was one anti-graffiti activity rated high in this survey for high school students, which is “Introducing a course about anti-graffiti in their curriculum”. For elementary and middle school students, no single countermeasure was rated outstanding. The relationship between the neighborhood and state DOTs was similar to with schools. It may be for the same reason as for with
schools. Encouraging graffiti reports from community was viewed as the most viable countermeasures from the perspective of relation with neighborhood. It may be due to fact that this approach may be very cost effective to state DOTs. Maybe it is for the same reason that police keeping eyes on the areas beyond the roads was another favorably chosen countermeasure. Not many states responded to the question about the relationship between local agencies and state DOTs. The activity Exchanging ideas and information about graffiti was viewed the most promising by these states responses.

Among the possible punishments for taggers, charging fines and making taggers involved in community service are favorable. The frequency and amount of the tagging were viewed as the most relative criteria in determining the level of punishments. Age was not the major factor to be considered. Imposing a tax on graffiti making tools was not a popular tool among the surveyed states. Consistent with a previous question on punishment, graffiti vandalism was viewed more as misdemeanor than felony.

Crime Prevention Through Environmental Design seems viable and two big states were adopting this approach. A quite number of states supported the aesthetic enhancement for mitigating graffiti vandalism, which is along with the view in the literature review. There were a few states having the practice of collecting graffiti data and use the data for their planning. This seems to be approach promising in future.
VISITS TO CITIES, COUNTIES AND DOTS

As a part of the research, several meetings were conducted with cities, counties and DOTs of different states to know their graffiti removal policies and prevention techniques. It is because the graffiti removal policies and preventive techniques vary from state to state. The meetings were conducted with the City of Los Angeles, the City of Phoenix, the City of Las Vegas, Clark County, Caltrans and NDOT. The following sections describe the summaries of the meetings.

5.1 City of Los Angeles

There are two major types of graffiti that appear on the structures of the City of Los Angeles: (1) Political Graffiti and (2) Individual Graffiti. It costs over $20 million a year to remove graffiti in the city, out of which around $50,000 gets from the offenders as restitutions.

Depending on the types of structure, there are generally three methods of removing graffiti. The first is paint over which is used on most walls and buildings. Contractors will try to match the existing color as closely as possible. The second is sand/water blasting which is used on unpainted concrete surfaces such as curbs, sidewalks, cinder block walls etc. It is suggested that sandblasting cannot be applied to the same place more than one time. The third is chemical removal, which is used on
surfaces such as metal light poles, street signs, trees, and traffic control boxes, etc. For cleaning graffiti on the traffic signs, a chemical called graffiti remover is used. ‘Paint Over’ the graffiti is found to be the most efficient graffiti removal technique for all other surfaces.

Some graffiti preventive techniques have been adopted by the City of Los Angeles to mitigate graffiti in the city. The countermeasures include security cameras for surveillance, anti-graffiti coatings, spectrometers for color matching, and strong enforcement laws. The cameras that the city uses for surveillance are motion activated and have bulletproof cases for security. The camera takes a snapshot when the motion is detected in that area. The cost of each camera ranges from $2,000 to $3,000. From the experience of the city, it was observed that these cameras are not effective as the pictures taken by them were blurred. The city has also mentioned that live video cameras are used by the Parks Department. These cameras were found to be most effective in catching the taggers as they record the spot when there is motion detected. These video cameras are much expensive and costs around $20,000 each.

5.2 City of Phoenix

In the City of Phoenix, the Neighborhood Services Department (NSD) has a graffiti busters program to deal with four problems: graffiti, tool leading, illegal signs and shopping carts. Among these four problems, graffiti is the major concern of the program for which the funds come from various sources like Community Development Block Grant (CDBG) funds, General Purpose (GPF) funds, and Restitution.
Graffiti Buster program has totally 24 employees specifically for removing graffiti in the city. Three employees working on a 7/10 basis are especially to receive calls of the complaints. On average, they received 1000 calls a day. Graffiti Busters have responded to over 240,000 calls of graffiti and removed graffiti from over 330,000 sites in the last 10 years. It has removed graffiti from over 63,000 sites in fiscal year 06-07. Based on current trends and with the additional staffing, Graffiti Busters will remove approximately 90,000 sites in this fiscal year.

Graffiti Busters maintains a graffiti database, which is used for daily operations such as dispatching graffiti removal crews and historic record. This database allows finding the age of the graffiti. This age will be useful for dispatching a graffiti removal crew and selecting the paint to remove graffiti. After a call for graffiti is verified, a crew will be allocated to the places, where graffiti was done. They first take the pictures of the graffiti and save them in the database, and then they remove graffiti. When removing graffiti, Graffiti Busters uses electronic spectrometers for color matching. The spectrometers are the instruments to match the paint color with the base color of the surface while painting on graffiti. Each spectrometer costs around $5000. A software is required for the system, which costs around $40,000. Picture showing the spectrometer is presented in Figure 14.
The program uses trucks equipped with pressure water blaster, paints with different colors, a spectrometer for color matching, a laptop, a camera to take picture of graffiti before cleaning, a long pipe type instrument for cleaning graffiti in the high locations. Pictures showing the trucks and equipment inside the truck are presented in Figure 15.
Various graffiti preventive techniques are in use by the Graffiti Busters program in City of Phoenix to get rid of graffiti from the city. These techniques include cameras for surveillance, spectrometers for color matching, neighborhood community programs, educational awareness, anti-graffiti advertising, retail store inspection, sharing of graffiti database and increasing penalties for graffiti. Under this program, there are totally 61
flash cameras for surveillance whose cost ranges from $5000 to $8000. These cameras run with solar power and have flash system.

Under neighborhood community programs, as of January 2008, Graffiti Busters has given volunteers 4,779 gallons of paint which is an 76% increase over last Fiscal Year same time. The program has around 16000 volunteers working against graffiti. The educational awareness was created using diverse ideas. One of them is to distribute color book to elementary school children. This book contains cartoon stories against graffiti. It was also identified that educational awareness works effective to elementary and middle school children rather than high school children. Figure 16 shows the cover page of the color book. Anti-graffiti advertising is adopted by distributing anti-graffiti brochures, which describe the Graffiti Busters program’s overview. Figures 17, 18, 19, 20 show the cover pages of these brochures.

NSD increased its frequency of retail store inspections to ensure graffiti products are kept non-accessible and over 25 retailers have been cited. It has also developed a new webpage interface for the police department, which allows graffiti detectives, precinct staff, gang squad and prosecutors to search the Graffiti Busters database to conduct searchers to assist in the apprehension and prosecution of graffiti vandals. Under legislation, the punishments to taggers were increased and the fines range from $300-$1000 with an additional 80% administrative fee. Another non-access ordinance was also passed by the City of Phoenix. According to this ordinance, people with age under 18 are not allowed to purchase graffiti making tools such as magic markers, slap tags and water gun (super soakers) and these tools will be placed in place where they cannot be easily accessible.
Figure 16. Graffiti Color Book for Children
(City of Phoenix, 2008)
Helping to Keep Our Neighborhoods Graffiti Free

Figure 17. Graffiti Busters Program Brochure
(City of Phoenix, 2008)
Figure 18. Don't Post Signs Brochure
(City of Phoenix, 2008)
Figure 19. Cart Pick Up Brochure
(City of Phoenix, 2008)
5.3. City of Las Vegas

‘Paint Over’ is the most successful technique for removing graffiti in the City of Las Vegas. The cost of paint is cheap that is around $12/gallon. The City cleans graffiti on traffic signs using chemical remover. It has 5-man power to clean graffiti and has 24
hr policy to remove graffiti, if they came to know about the case. They get complaints and go to their regions every day. Each person will work ten hours a day. Each person will have a truck containing computers, camera and other equipment to clean graffiti.

The graffiti prevention techniques that were in use in the City of Las Vegas are security cameras, natural surveillance, graffiti tracker and educational awareness. City doesn’t use anti-graffiti coatings, as they are expensive. While painting over on graffiti, city doesn’t use electronic spectrometers for color matching, as the process is time consuming. Three basic colors: Block Brown, Block White and Block Grey are used by the city while painting over on graffiti, as most of the city structures are having one of these colors or close to these colors.

Security cameras are found to be more effective in graffiti-prone areas. Figure 21 shows the picture of the camera and the picture of photo taken by the camera. These cameras are found to be more effective in mitigating graffiti. Each camera costs around $6000 and will have a 5-year warranty. These cameras work in the nighttime also. It has motion sensor, own flash system, own battery system and voice. The cameras will have a strong protective system so that taggers can’t damage them. The system requires a wireless laptop, which would be kept at 100 ft away from camera. The laptop downloads pictures from camera directly. A bright light with motion detective systems on the back of the sound walls is found to be a good idea to mitigate graffiti in that area. City is planning to use “Graffiti Tracker”, which is a program to analyze the graffiti made by taggers and finding the taggers, who made the graffiti. It costs 1$ for downloading 1 picture into tracker program and the city will download 60000 pictures per 1 year.
Educational awareness is also adopted by the city. City marshals go to schools to give lectures to children.

Security Camera for Graffiti Vandalism

Photo Taken by the Camera

Figure 21. Camera for Graffiti Monitoring (City of Las Vegas, 2008)
5.4 Comparison of Graffiti Removal and Prevention among Cities

In this section, graffiti removal and prevention techniques among the three cities visited were compared. Tables 10 and 11 present the comparison of graffiti removal and prevention techniques. It can be observed from Table 10 that ‘paint over’ is adopted by all the three cities for removing graffiti as it is most cost-effective technique. For traffic signs, chemical removal was in use in all the cities. No city prefers sand blasting technique and only Phoenix is implementing water-blasting technique for limited surfaces.

Table 10: Graffiti Removal among Cities

<table>
<thead>
<tr>
<th>Activity / Technique</th>
<th>City of Las Vegas</th>
<th>City of Phoenix</th>
<th>City of Los Angeles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Over</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chemical Removal (for signs)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sand Blasting</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Water Blasting (Pressurized water sprays)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Educational awareness, enforcing anti-graffiti laws and encouraging citizen reporting are the prevention techniques adopted by the three cities discussed above. Cameras are proved to be successful in City of Las Vegas and City of Phoenix but not in City of Los Angeles, as they use some low quality cameras. No city has preferred anti-graffiti coatings, as they are more expensive. Fencing to the bridges is also suggested by the cities. Landscaping to sound walls is preferred by City of Phoenix and City of Los Angeles but not by City of Las Vegas due to water problems in Nevada. Cameras are
proved to be successful in City of Las Vegas and City of Phoenix but not in City of Los Angeles, as they use some low quality cameras. No city has preferred anti-graffiti coatings, as they are more expensive.

Table 11: Graffiti Prevention among Cities

<table>
<thead>
<tr>
<th>Activity/ Technique</th>
<th>City of Las Vegas</th>
<th>City of Phoenix</th>
<th>City of Los Angeles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameras</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Anti-Graffiti Coatings</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fencing to Bridges</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Landscaping to sound walls</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Anti-Graffiti Panel</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Rat Guards</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Graffiti Shields</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Educational Awareness</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Facilitating Legal Graffiti</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Enforce Anti-Graffiti Laws</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Encourage Citizen Reporting</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rapid Removal</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

5.5 Clark County in Nevada

Clark County has several divisions involved in graffiti removals and preventions: Public Works, Parks & Recreation department, and Traffic. It removes racial and profane graffiti as soon as it is noticed. Basically, County deals with graffiti on residential structures. For the graffiti on business or commercial structures, county charges for cleaning or removing graffiti. Parks & Recreation Department and Public Works (PW) Department of Clark County have their own policies for removing graffiti. Parks & Recreation department has its own crew to remove graffiti. Some of the facilities on which, Parks & Recreation Dept cleans graffiti are swimming pools, gyms, administrative
offices and bathrooms. The graffiti on these facilities will be cleaned as soon as it would be noticed.

Public Works cleans graffiti that is anything right of way, on-off ramps, on street light poles, sidewalks, flood channels etc. Public works department has two contractors to remove graffiti one on the strip and another on the resort corridor. The total cost of the contract for both areas is around $830,000 a year. The cost of the contract to deal with graffiti only on strip is around $258,000. The graffiti would be cleaned on 5 days a week basis. The boundaries of the resort corridor that PW deals are Sahara Ave, S Maryland Pkwy, Tropicana Ave and S Valley View Blvd. These boundaries are marked red in Figure 22.

Figure 22. Boundaries of Resort Corridor
Primarily, the county uses paint over technique to clean graffiti. It also uses pressurized hot water sprays that are environmentally friendly to clean graffiti on the surfaces. It doesn’t use anti-graffiti coatings as they are proved to be more expensive and less effective. Only for bridge elevators, county uses film coatings. Parks & Recreational department uses some sacrificial anti-graffiti coatings. For cleaning graffiti on the signs, county uses graffiti remover, which was proved to be successful. Picture of graffiti remover can is presented in Figure 23.

![Graffiti Remover](image)

Figure 23. Graffiti Remover (Clark County, 2008)

County doesn’t use any color matching spectrometers while cleaning graffiti. Basically, county uses seven standard colors for paint over: Phantom Gray, Adobe Brown, Sand Stone, Idaho Gray, Intimate White, White, and Buff Yellow. It provides all these paints for free to remove graffiti. Figure 24 presents some of the colors. Only Maintenance & Management Division has color matching trucks to clean graffiti on flood channels.
In Clark County, the following graffiti countermeasures are being adopted: strong enforcement laws, educational awareness, landscaping to sound walls, cameras for surveillance and information sharing among various anti-graffiti agencies. Strong enforcement laws are in terms of punishments to taggers. The punishments include putting the taggers in jail, making them involve in community service and canceling the driver's license. As per the Clark County experience, it is not so difficult to catch taggers, if the law enforcement agency works with good determination in catching taggers because taggers are localized to certain areas. Catching the taggers becomes easy, if their psychology was understood properly. It was also mentioned that determined enforcement in catching the taggers could replace the usage of ‘Graffiti Tracker’ program, which is expensive software used to read the graffiti and to identify the taggers.

According to Clark County, Educating students in school levels is a good idea to prevent graffiti. Video shows, posters might be presented in the classrooms. In some
schools, at 5th grade, Anti-graffiti video session has become mandatory. Usually, schools call county to give presentations to the students. According to Clark County sources, the anti-graffiti education should start in elementary school levels (from the 2nd and 3rd grade) itself so that it can work out effectively. Anti-graffiti policies are advertised through websites, hotline, anti-graffiti materials and other news related activities. There are some anti-graffiti volunteer groups, which were successful in mitigating graffiti in the Clark County. County does not prefer cameras for surveillance of graffiti related activities, as they are more expensive and each camera costs around $6000 that needs additional manpower to monitor. County prefers to meet with other cities, house owners associations (HOA), private agencies, police and other anti-graffiti agencies for data sharing and combat together against graffiti to get rid of it.

5.6. California Department of Transportation (Caltrans)

Caltrans crew doesn’t clean graffiti on daily basis. They will clean graffiti when somebody caught in tagging or when they receive complaints to remove graffiti. Rapid removal of graffiti is not effective in California. They clean normal graffiti once a month and clean offensive graffiti as soon as possible. ‘Paint Over’ on graffiti is the only successful graffiti removing technique adopted in Caltrans. Sand Blasting technique is not used as it takes lot of time and can be applied only once on a surface.

In Caltrans, some graffiti preventive techniques are also adopted such as fencing to the bridges, landscaping to sound walls, preventive access devices to signs such as rat guards, sign shields, and deterrent wires such as Constantine wire or barb wire. From the Caltrans practical experience, it was observed that most inaccessible areas such as
underside of the bridge decks are hot spots for taggers. It was also identified that graffiti occurs more in summer and spring terms. Landscaping to the sound walls was one of the best measures in preventing graffiti from the sound walls in California. Landscaping is proposed in design of all the sound walls in future. Previously, ‘Ficus’ plant is used for landscaping, but is difficult to maintain after getting old. Now, they are using ‘Boston Ivy’ for landscaping, which is the best type of vine to use in the district’s climatic regions. This plant is drought resistant and grown well in typical desert and minimal rain mountainous terrains. Two-year rain cycle is enough for maintenance. Nothing is required except low flow water systems with sound wall surfaces at $2.30 per square feet of Ivy installed. All landscape projects are established with 3-year plant establishment period. Figure 8 in the literature review presents the landscaping on sound walls in California.

There are various preventative access devices such as rat guards, sign shields and deterrent wires such as Constantine wire or barbwire in use to prevent the access of taggers to the traffic signs. There are totally 1720 traffic signs in Los Angeles but are only limited rat guards installed. Rat guards and sign shields are usually expensive and are required to be customized for airspace issues. Average price per unit varies from $1500 to $3500 for rat guard types that may or may not have a hatch for access. The costs of rat guards and graffiti shields that Caltrans is using are much higher than that were used by NDOT. That is the reason why, barbwire and concertina wire are in use in Caltrans to prevent the access of taggers to the traffic signs. Figure 10 in the literature review presents the picture of concertina wire or barbwire attached to sign pole.
Caltrans doesn’t use security cameras for surveillance. Highway patrolling is more in California, which in turn can be useful as surveillance for graffiti vandals. It was indicated that Aesthetic enhancement of the structures is suggested as a good solution to prevent graffiti. If a structure is enhanced with some beautiful arts, there is less likelihood that those structures are affected by graffiti.

5.7 Nevada Department of Transportation

Removing graffiti from highway infrastructure is a big task for maintenance divisions in NDOT. It is not only difficult to remove graffiti from the girders and abutments of the bridge but also risky as the traffic on the freeways is a big issue of safety. NDOT District 1 devotes over 10,000 man-hours per year on Las Vegas graffiti removal. The graffiti removing crew wears personal protective equipment, from masks to footies. They use paint sprayers, rollers and brushes to cover the graffiti with paint. 'Paint Over' is the most efficient graffiti removal technique in use. The biodegradable paints come in nearly 20 different colors to match different freeway structures throughout the Las Vegas area. The standard color paint costs around $20 a gallon and it takes around 30 second per square foot to apply paint. Pressure washing, sand blasting, water blasting and chemical removal are some other graffiti removal techniques used by NDOT. Sand blasting was not preferred as the process is expensive, time intensive and can be applied only once for a surface. 'Chemical Removal' is used for cleaning graffiti on the traffic signs. The picture in Figure 25 shows the can of 'Graffiti Remover', a chemical used to remove graffiti on the traffic signs. This product is proved to be 85% efficient. It costs around $231.2 for five gallons.
NDOT has been looking for innovative countermeasures to prevent graffiti from the highway infrastructures. Some of the measures that were already in use are fencing for bridges, Rat guards for the traffic sign poles, graffiti shields for the signs, and graffiti panel on bridges. The pictures of rat guard, graffiti shield and anti-graffiti panel are presented in the literature review. The rat guards and graffiti shields are designed by the in house welders of NDOT, which reduces their cost significantly. NDOT has tried some anti-graffiti coatings to some surfaces. The purpose of these coatings is to protect the substrate and make the removal of graffiti easy. A non-sacrificial coating named ‘Erasol’ was in use by NDOT. However, practically, these coatings are proved to be unsuccessful. The cost of these coatings is much high that is $52 per a gallon.

From all the above visits to cities, counties and DOTs several graffiti countermeasures that are effective, their costs and benefits were identified for evaluation.
CHAPTER 6

INVENTORY DATA ANALYSIS

This chapter provides the analysis of the inventory data that was collected as mentioned in the methodology.

6.1 Bridges and Sound Walls in Las Vegas Area

In this study, the graffiti data on the bridges and sound walls were collected for the major highways I-15, I-215, US 95, I-515 and Summerlin in the Las Vegas area. The specific locations of the bridges and sound walls for which graffiti data were collected are presented in Figure 26 to Figure 29. The number of graffiti cases, area of graffiti, accessibility to the structure, availability of fencing, land use of the surroundings and the community nature are noted for both bridges and sound walls. For sound walls, back side of the sound walls were also collected for graffiti data on some freeways.

The data was collected twice, one in 2007 that contains the graffiti data between the year of construction of the structure and 2007; and another is in 2008 that contains the graffiti data between 2007 and 2008. The reason behind this is to know the frequency of graffiti in the recent one-year period. Table 12 presents the descriptive statistics of the graffiti data for the bridges in the Las Vegas area collected in 2007. It was observed from the table that, although the number of bridges on the Resort Corridor is much less than the other roadways I-215, I-515 and US-95, the number of graffiti cases is much higher
than the other roads. The reason might be that the bridges on Resort Corridor are close to the strip. As the frequency of visitors to the strip is more, the likelihood that taggers are from these visitors is more. Although the number of graffiti cases on I-15 is less than that of I-215, the total area of graffiti is almost double to that of I-215. Most of the bridges on all the roadways have entrance to the bridge components. This means, entrance might not have any impact on graffiti.

It was also observed that most of the bridges on Resort Corridor and I-15 don’t have fence, where as most of the bridges on I-215, US-95 and I-515 have fence, which indicates that the bridges having fence have less number of graffiti cases than those bridges that don’t have fence. It was also observed that most of the bridges on Resort Corridor and I-15 have commercial surroundings. One more observation is that the neighborhood communities of the bridges on I-215 are all good, where as most of the communities on Resort Corridor and I-15 are bad. The nature of the community was decided by the crime rate in that area. On bad communities, crime rate is high, thus graffiti vandalism is also higher than good communities. Table 13 provides the descriptive statistics for graffiti data for bridges in the Las Vegas area in 2008. It was observed from the table that the graffiti on the bridges of Resort Corridor and I-15 was relatively more than the other roadways. The reason might be the same as discussed before. The average graffiti on US 95 was higher than that of I-215 in 2008. The reason might be that some tagger gangs are moved to the surroundings of US 95. I-515 was less affected by graffiti, which is in consistent with the data collected in the previous year.

Table 14 gives the descriptive statistics of the graffiti data for sound walls in the Las Vegas area in 2007. It was observed from the table that, although the number of
sound walls on I-15 and I-515 are less, when compared to the number of sound walls on I-215 and US-95, the number of graffiti cases is much more than I-215 and US-95. It can be also observed from the table that most of the sound walls on all the freeways have residential surroundings.

Another observation is that the neighborhood communities of the sound walls on I-215 and US-95 are good whereas these are bad for most of the sound walls of I-15 and I-515. The table also shows that although there was no fencing on the corners of the sound walls on I-215, there was very less graffiti, which implies that fencing, has no significant impact on the graffiti on sound walls on I-215. There are only two sound walls on Summerlin and Resort Corridor and these sound walls were pretty clean with no graffiti on them. Table 16 provides the descriptive statistics for sound walls in Las Vegas area in 2008. It can be seen from the table that the two sound walls in Resort Corridor area are attacked in between 2007 and 2008. The data collected in 2008 was not in consistent with 2008. More graffiti vandalism has occurred on US 95, I-515 and I-215 than I-15 and Resort Corridor. The reason might be the same as for bridges that in the recent year more tagger gangs might be moved to US 95 and I-515. The sound walls on Summerline were not vandalized.
Figure 26. Bridges for Which Graffiti Data Were Collected in the Las Vegas Area
Figure 27: Bridges for Which Graffiti Data Were Collected in the Las Vegas Area (cont.)
Figure 28. Segments of Sound Walls for Which Graffiti Data Were Collected in the Las Vegas Area
Figure 29: Segments of Sound Walls for Which Graffiti Data Were Collected in the Las Vegas Area (cont.)
Table 12: Descriptive Statistics for Bridges in the Las Vegas Area in 2007

<table>
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<tr>
<th></th>
<th>Resort Corridor</th>
<th>I-15</th>
<th>I-215</th>
<th>US 95</th>
<th>I-515</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Bridges</td>
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<td>21</td>
<td>27</td>
<td>17</td>
<td>9</td>
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<tr>
<td>Total number of graffiti cases</td>
<td>55</td>
<td>53</td>
<td>35</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Total area of graffiti (ft²)</td>
<td>269.8</td>
<td>493.86</td>
<td>251.28</td>
<td>55.52</td>
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</tr>
<tr>
<td>Graffiti Area on Average (ft²)</td>
<td>53.96</td>
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<td>9.31</td>
<td>3.08</td>
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<tr>
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Table 13: Descriptive Statistics for Bridges in Las Vegas Area in 2008

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<th></th>
<th>Resort Corridor</th>
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<th>US 95</th>
<th>I-515</th>
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<td># of Bridges</td>
<td>5</td>
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<td>27</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Total number of graffiti cases</td>
<td>16</td>
<td>27</td>
<td>6</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Total area of graffiti (ft²)</td>
<td>26.17</td>
<td>118.31</td>
<td>32.76</td>
<td>36.59</td>
<td>8.85</td>
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<td>Graffiti Area on Average (ft²)</td>
<td>5.23</td>
<td>5.63</td>
<td>1.21</td>
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<tr>
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</tr>
<tr>
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Table 14: Descriptive Statistics for Sound Walls in the Las Vegas Area in 2007

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<tr>
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<th>Resort Corridor</th>
<th>I-15</th>
<th>I-215</th>
<th>US95</th>
<th>I-515</th>
<th>Summerlin</th>
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<tbody>
<tr>
<td># of Sound wall Segments</td>
<td></td>
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<td>6</td>
<td>26</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Length in Total</td>
<td>0.92</td>
<td>8.41</td>
<td>23.82</td>
<td>18.48</td>
<td>24.06</td>
<td>0.74</td>
</tr>
<tr>
<td>Length on Average</td>
<td>0.46</td>
<td>1.40</td>
<td>0.92</td>
<td>1.16</td>
<td>1.85</td>
<td>0.37</td>
</tr>
<tr>
<td># Total of graffiti</td>
<td>0</td>
<td>42</td>
<td>9</td>
<td>9</td>
<td>49</td>
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</tr>
<tr>
<td>Total Area of Graffiti (ft²)</td>
<td>0</td>
<td>453.60</td>
<td>81</td>
<td>103.71</td>
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<td>75.6</td>
<td>3.12</td>
<td>6.48</td>
<td>48.95</td>
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<tr>
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</tr>
<tr>
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<td>4</td>
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<tr>
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<td>Community</td>
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</tr>
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<td>Good</td>
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<td>0</td>
<td>0</td>
<td>25</td>
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</tr>
<tr>
<td>Bad</td>
<td></td>
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<td>6</td>
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</tr>
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<td>1</td>
</tr>
</tbody>
</table>
Table 15: Descriptive Statistics for Sound Walls in Las Vegas Area in 2008

<table>
<thead>
<tr>
<th></th>
<th>Resort Corridor</th>
<th>I-15</th>
<th>I-215</th>
<th>US95</th>
<th>I-515</th>
<th>Summer lin</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Sound wall</td>
<td>2</td>
<td>6</td>
<td>26</td>
<td>16</td>
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<td>2</td>
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<tr>
<td>Segments</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length in Total</td>
<td>0.92</td>
<td>8.41</td>
<td>23.82</td>
<td>18.48</td>
<td>24.06</td>
<td>0.74</td>
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<tr>
<td>Length on Average</td>
<td>0.46</td>
<td>1.40</td>
<td>0.92</td>
<td>1.16</td>
<td>1.85</td>
<td>0.37</td>
</tr>
<tr>
<td># Total of graffiti</td>
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<td>14</td>
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<td>0</td>
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<td>Total Area of Graffiti (ft²)</td>
<td>39</td>
<td>68</td>
<td>118.9</td>
<td>282.24</td>
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<td>Graffiti Area on Average (ft²)</td>
<td>19.5</td>
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<td>4.57</td>
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<td>12</td>
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<td>1</td>
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</tr>
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<td>3</td>
</tr>
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<td>3</td>
<td>1</td>
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<td>Residential/Commercial</td>
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<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
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6.2 Bridges and Sound Walls in the Reno Area

In this study, the graffiti data on the bridges and sound walls were collected for the major highways I-80 and I-395 in the Reno area. The specific locations of the bridges and sound walls for which graffiti data were collected are presented in Figures 30 and 31.

Table 16 presents the descriptive statistics of the graffiti data for the bridges in the Reno area in 2007. From the table, it can be observed that, although there is a big difference in the total number of graffiti cases on the bridges of I-80 and US-395, the total area of graffiti is almost same. Majority of the bridges on US-395 don’t have
graffiti. But the high total area on US-395 is due to the fact that more graffiti was occurred on selective bridges. The reason might be that taggers were localized in these areas. All the bridges of I-80 and US-395 have entrance to the structure. It was also observed that most of the bridges in Reno don’t have fencing to the bridges. Majority of the bridges in Reno have commercial surroundings, where as some bridges have a mix of commercial and residential surroundings. The quality of neighborhood community was not discussed for the structures in Reno area, as those are not familiar. Table 17 provides the descriptive statistics for bridges in Reno area in 2008. It was observed that the graffiti in the period between 2007 and 2008 has increased a lot on both I-80 and US-395 bridges. Surprisingly, the average area of graffiti in this one-year period is higher than that of all the years from the year of construction of the structure to 2007. This indicates that bridges in Reno have become as hot spots for the taggers in the recent year.

Table 18 gives the descriptive statistics of the graffiti data for sound walls in the Reno area in 2007. The number of sound walls in Reno is less than that of Las Vegas. From the table it can be observed that there is no graffiti on the sound walls of I-80. Although the total area of graffiti on the sound walls of US-395 is more, most of the graffiti was on a single sound wall, which is on US-395 at S Virginia St. The graffiti on this sound wall was on the back of the sound wall. All the sound walls on I-80 and majority of the sound walls on US-395 have fencing on the corners to prevent the access of taggers to the back of the sound walls. This fencing blocks the whole area between the back of the sound wall and the wall surrounding the adjacent residential areas, which is not in case of Las Vegas area. It indicates that fencing on the corners of the sound wall has significant impact in mitigating graffiti on the sound walls in Reno area. The sound
walls in Reno have area have all types of surroundings such as residential, commercial and mix of these two. However, the sound wall on US-395 at S Virginia St, which has more graffiti, has residential surroundings with no fencing to prevent the access of taggers to the back of the sound wall. More tagger gangs might be localized in this location. Table 19 provides the descriptive statistics for sound walls in Reno area in 2008. It can be observed from the table that sound walls on I-80 are not attacked by the taggers in the recent year also. But the sound walls on US 395 are seriously attacked by the vandals as in case of previous years. The reasons might be the same as discussed before.
Figure 30. Bridges for Which Graffiti Data Were Collected in the Reno Area
Figure 31. Segments of Sound Walls for Which Graffiti Data Were Collected in the Reno Area
Table 16: Descriptive Statistics for Bridges in the Reno Area in 2007

<table>
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<tr>
<th></th>
<th>I-80</th>
<th>US-395</th>
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<tbody>
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<td># of Bridges</td>
<td>19</td>
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</tr>
<tr>
<td>Total number of graffiti cases</td>
<td>86</td>
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<tr>
<td>Total area of graffiti (ft²)</td>
<td>494.6</td>
<td>501.1</td>
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<td>Graffiti Area on Average (ft²)</td>
<td>26.03</td>
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<td>16</td>
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<tr>
<td>Fence</td>
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<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Residential</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Commercial</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Residential/Commercial</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>No Development</td>
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</tr>
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Table 17: Descriptive Statistics for Bridge in Reno Area in 2008

<table>
<thead>
<tr>
<th></th>
<th>I-80</th>
<th>US-395</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Bridges</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Total number of graffiti cases</td>
<td>51</td>
<td>103</td>
</tr>
<tr>
<td>Total area of graffiti (ft²)</td>
<td>551.85</td>
<td>876.73</td>
</tr>
<tr>
<td>Graffiti Area on Average (ft²)</td>
<td>29.04</td>
<td>54.80</td>
</tr>
<tr>
<td>Entrance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Residential</td>
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<td>1</td>
</tr>
<tr>
<td>Commercial</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Residential/Commercial</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>No Development</td>
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<td>0</td>
</tr>
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Table 18: Descriptive Statistics for Sound Walls in the Reno Area in 2007

<table>
<thead>
<tr>
<th></th>
<th>I-80</th>
<th>US 395</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Sound wall Segments</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Length in Total (miles)</td>
<td>2.22</td>
<td>3.88</td>
</tr>
<tr>
<td>Length on Average (miles)</td>
<td>0.44</td>
<td>0.43</td>
</tr>
<tr>
<td>Total # of graffiti</td>
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<td>40</td>
</tr>
<tr>
<td>Total Area of Graffiti (ft²)</td>
<td>0</td>
<td>554.8</td>
</tr>
<tr>
<td>Graffiti Area on Average (ft²)</td>
<td>0</td>
<td>39.63</td>
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<tr>
<td>Entrance</td>
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<td></td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>8</td>
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<tr>
<td>Fence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
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<td>4</td>
</tr>
<tr>
<td>Residential</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Commercial</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Residential/Commercial</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>No Development</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 19: Descriptive Statistics for Sound Walls in Reno Area in 2008

<table>
<thead>
<tr>
<th></th>
<th>I-80</th>
<th>US 395</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Sound wall Segments</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Length in Total (miles)</td>
<td>2.22</td>
<td>3.88</td>
</tr>
<tr>
<td>Length on Average (miles)</td>
<td>0.44</td>
<td>0.43</td>
</tr>
<tr>
<td>Total # of graffiti</td>
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<td>34</td>
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<tr>
<td>Total Area of Graffiti (ft²)</td>
<td>0</td>
<td>171.48</td>
</tr>
<tr>
<td>Graffiti Area on Average (ft²)</td>
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<td>19.05</td>
</tr>
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<td>Entrance</td>
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<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Fence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Residential</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Commercial</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Residential/Commercial</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>No Development</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
6.3 Regression Models

The factors that influenced the amount of graffiti on bridges and sound walls in the Las Vegas area were identified through developing linear regression models. The number of bridges and sound walls for which graffiti data were collected in the Reno area was small and thus linear regression models were not developed for them. The factors considered in the linear regression models for the graffiti on bridges are roadways that were attacked, the land use type, and quality of a neighborhood. The roadways for which graffiti data for bridges walls were collected were I-15, I-215, US95, and I-515. These roadways are the primary Interstate and state highways that are maintained by NDOT. Some of these roads are more prominent than the others. For example, I-15 carries significant amount of traffic flow than others and it runs in parallel to the world known Strip. The anxiety of taggers for exposing their work may drive them more to tag on this road than the others. Certain land use may tend to create opportunity for taggers. Whether there were fences on bridges or not, may determine the occurrences of graffiti. With fences, which may be installed even for pedestrian not for graffiti prevention, the chance for taggers reaching to the surface of bridges can be reduced. The types of land use considered in the modeling are residential, commercial, mix of residential and commercial, and no development. Some communities may be more violate and tend to produce more taggers than others. Thus, a factor representing the quality of a neighborhood was used.

The results of the linear regression model are presented in Figure 32. It can be seen in the table that the coefficient for the variable representing I-15 is positive and statistically significant. In the modeling, the variable representing I-215 was used as the
base that other roads can compare with. The variables for the roads I-515 and US 95 are not significant in the result, which implies that the amount of graffiti on the bridges on these two roads was the same as that on I-215. The coefficient for I-15 is positive. This result indicates that the amount of graffiti tagged on the bridges of I-15 was more than those on the other roads. Another variable that is statistically significant is the one representing fencing available on a bridge. Its coefficient is negative, and thus indicates that the bridges with fences installed had less graffiti on average. This result is consistent with intuitive and implies that fencing can be used as a countermeasure for graffiti. The variables for land use and community quality are not significant in the results. This indicates that these two factors did not contributing to the occurrence of graffiti on bridges. Specifically, the amount of graffiti on a bridge located in a residential area would be the same as the bridges located on other types of land uses such as commercial or mix land use. The amount of graffiti on a bridge located in a bad community would be the same as those in a good community.

In modeling the graffiti on sound walls in the Las Vegas area, the following factors were considered: the roadways that were tagged, whether there were graffiti on the back of a sound wall inspected, the length of a sound wall, whether there was fencing around a sound wall, the land use type, and quality of a neighborhood. The factors whether graffiti on the back of sound wall was found and the length of a sound wall is special to sound walls than bridges. It was found in interviewing the NDOT District 1 maintenance crew that there are many graffiti on the back of sound walls. Taggers may easily access these sound walls since there were no protections such as landscapes for them. A perception may be that a sound wall with longer length may provide higher
exposure to taggers than one with shorter length.

The results in Figure 33 show that only I-15 has its variable significant. In the modeling, I-515 was used as the base to compare with other roads. The positive coefficient for I-15 implies that there were more graffiti on the sound walls on I-15 than those on other roads. One step further, the sound walls with graffiti found on their back were compared. The variable for the sound walls on I-515 with graffiti found on their back is statistically significant. It implies that the back of the sound walls on I-515 was more heavily tagged than the sound walls on other roads with graffiti on their back tagged and also more heavily tagged than the sound walls (regardless of with graffiti on the back) on other roads.

The length of sound wall has a negative coefficient, which suggests that it may not appropriate to expect more graffiti for a long sound wall. Graffiti may cluster around a certain location. The amount of graffiti on a unit length of sound wall diminished with the length of sound walls. The variable representing residential area where a sound wall was located has a significant positive coefficient. This indicates that a sound wall located in a residential area tended to be more heavily tagged than located on other type of areas such as commercial area. It might be due to the perception that the residential area may have the potential to generate someone to tag sound walls that are close to them.
Figure 32. Results of Linear Regression Models for Bridges in the Las Vegas Area

********** ORDINARY LEAST SQUARES ESTIMATION **********

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>19.14309</td>
<td>6.72865</td>
<td>2.84501</td>
</tr>
<tr>
<td>i15</td>
<td>15.66330</td>
<td>8.32820</td>
<td>1.88075</td>
</tr>
<tr>
<td>fence</td>
<td>-20.18658</td>
<td>7.83235</td>
<td>-2.57733</td>
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</tbody>
</table>

|                           |                       |                |             |
| Number of Observations   | 79                    |                |             |
| R-squared               | 0.16913               |                |             |
| Corrected R-squared     | 0.14727               |                |             |
| Sum of Squared Residuals| 8.06763e+004          |                |             |
| Standard Error of the Regression | 32.58114 |                |             |
| Durbin-Watson Statistic | 1.20846               |                |             |
| Mean of Dependent Variable | 13.82152            |                |             |
**Figure 33. Results of Linear Regression Models for Sound Walls in the Las Vegas Area**

**Ordinary Least Squares Estimation**

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
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<td>9.48495</td>
<td>1.38408</td>
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<tr>
<td>115</td>
<td>54.87207</td>
<td>15.15288</td>
<td>3.62123</td>
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<tr>
<td>i515back</td>
<td>94.79044</td>
<td>17.01724</td>
<td>5.57026</td>
</tr>
<tr>
<td>leng</td>
<td>-21.39356</td>
<td>7.06678</td>
<td>-3.02734</td>
</tr>
<tr>
<td>resi</td>
<td>21.84036</td>
<td>10.28799</td>
<td>2.12290</td>
</tr>
</tbody>
</table>

Number of Observations: 65  
R-squared: 0.40062  
Corrected R-squared: 0.36066  
Sum of Squared Residuals: 9.37156e+004  
Standard Error of the Regression: 39.52122  
Durbin-Watson Statistic: 1.95141  
Mean of Dependent Variable: 20.61092
CHAPTER 7

COST-BENEFIT ANALYSIS

From the literature review, survey to state DOTs, visits to cities, counties and DOTs, and the inventory data analysis, a spectrum of countermeasures that were uniquely found for preventing graffiti on highways is identified. Figure 34 provides these countermeasures from these sources. As a result, the countermeasures evaluated for their benefits and costs are (1) fencing, (2) rat guards or graffiti guards, (3) graffiti shields, (4) security cameras, (5) anti-graffiti coatings, (6) electronic spectrometers, (7) graffiti tracker, and (8) electronic database.
<table>
<thead>
<tr>
<th>Literature Review</th>
<th>Survey</th>
<th>Visits</th>
<th>Inventory</th>
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<tbody>
<tr>
<td>- Pedestrian fence</td>
<td>- Pedestrian fence</td>
<td>- Pedestrian fence Caltrans, NDOT, ADOT</td>
<td>- Pedestrian fencing, Fence on corners</td>
</tr>
<tr>
<td>- Fence on corners</td>
<td>- Fence on corners</td>
<td>- Fence on corners (Caltrans, NDOT)</td>
<td>- Fence on corners</td>
</tr>
<tr>
<td>- Rat Guards</td>
<td>- Rat Guards</td>
<td>- Rat guards, Graffiti shields (Caltrans, NDOT)</td>
<td>- Rat guards, Graffiti shields (Caltrans, NDOT)</td>
</tr>
<tr>
<td>- Graffiti shields</td>
<td>- Graffiti shields</td>
<td>- Graffiti shields (Caltrans, NDOT)</td>
<td>- Graffiti shields</td>
</tr>
<tr>
<td>- Security cameras</td>
<td>- Security cameras</td>
<td>- Security cameras (Caltrans, NDOT)</td>
<td>- Security cameras (Caltrans, NDOT)</td>
</tr>
<tr>
<td>- Anti-graffiti coatings</td>
<td>- Anti-graffiti coatings</td>
<td>- Educational awareness</td>
<td>- Anti-graffiti coatings (CC, NDOT)</td>
</tr>
<tr>
<td>- Electronic spectrometers</td>
<td>- Electronic spectrometers</td>
<td>- Electronic database</td>
<td>- Electronic database (CLV, CLA, ADOT)</td>
</tr>
<tr>
<td>- Graffiti tracker</td>
<td>- Graffiti tracker</td>
<td>- Educational awareness</td>
<td>- Educational awareness</td>
</tr>
<tr>
<td>- Electronic database</td>
<td>- Electronic database</td>
<td>- Clean neighborhood</td>
<td>- Clean neighborhood</td>
</tr>
<tr>
<td>- Educational Awareness</td>
<td>- Educational Awareness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Clean neighborhood</td>
<td>- Clean neighborhood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Strong law enforcement</td>
<td>- Strong law enforcement</td>
<td></td>
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</tr>
</tbody>
</table>

Cost and Benefit Study

Pedestrian fencing, fence on corner, rat guards, graffiti shields, security cameras, coating, spectrometers, graffiti tracker, database

Figure 34. Countermeasures Identified from Various Sources
7.1 Pedestrian Fencing to Bridges

Costs:

The total costs for pedestrian fencing on a bridge include capital cost to purchase the material such as fences, installation costs for labor and equipment such as vehicles moving fences to the bridge for installation and devices digging holes for poles connecting fences, and maintenance costs if there are any breakings by vandals throughout the life span of the fence. According to Caltrans (see Appendix III), the capital cost for one linear square foot is $2.70, and the installation cost for one linear square foot is $6.20. For a bridge with 200 feet long and 5.8 feet high fence on the top of the bridge in Las Vegas and Reno, the capital cost for this bridge can be calculated as: $2.70 \times 200 \times 5.8 = $3,132. The installation cost for this bridge comes to: $6.20 \times 200 \times 5.8 = $7,192.

Figure 35. Pedestrian Fence (Photo Taken by Research Team in 2008)
Among the total costs involved in a bridge with pedestrian fencing, the capital and installation costs are the investments in the first year only. The maintenance costs are distributed throughout the lifetime of the fence. In this study, the lifetime of pedestrian fence was assumed as 25 years. So, the maintenance costs have to be converted to the present value for the total costs incurred over the 25 years. Assuming a uniform series of maintenance costs throughout the life span of the fence and interest rate to the present value, the present value of the uniform maintenance cost can be calculated by using the following formula:

\[
P_{MC} = U_{MC} \times \left( \frac{(1+i)^n - 1}{i(1+i)^n} \right)
\]  

(7.1)

where

- \(P_{MC}\) = Present value of the uniform maintenance cost
- \(U_{MC}\) = Uniform series maintenance cost
- \(n\) = Number of years
- \(\left( \frac{(1+i)^n - 1}{i(1+i)^n} \right)\) = Uniform series present worth factor (USPWF)

It is assumed that a damaged caused to the pedestrian fence happens once a year, each with the area of four square feet, a number obtained from the inventory data collection in this study. According to Caltrans, the maintenance cost for one square foot of a problem area is $37.2. Then, the maintenance cost per year can be calculated as 

\[1 \times 4 \times $37.2 = $148.8\]

Then, the maintenance cost for the life time of the fence can be derived as 

\[10.67 \times 148.8 = 1,588.41\]

where 10.67 is the uniform series present worth factor that is calculated using the formula in Equation (7.1) with the interest rate at 0.08.
Therefore, the total net present value of the total costs = $3,132+$7,192+$1,588.41 = $11,912.41.

Benefits:

Benefit of using pedestrian fencing can be observed in terms of reduction in the number of graffiti cases, which can reduce the high graffiti removal costs. From the inventory data collected in this study, it was observed that the average area of graffiti on a bridge without fencing is 28.9 square feet per year. As mentioned earlier, the graffiti removal costs include the cost of paint to remove graffiti, the labor and equipment costs, and other major costs such as traffic lane closure costs. According to NDOT, the average paint cost for one square foot of graffiti removal is $2.00. Assuming $50,000 annual salary for the labor with 0.5 fringe and benefits, the hourly rate of the labor is $36.13. The hourly rate of the graffiti removal equipment was assumed as $50. Considering that two persons with one equipment are needed for removing graffiti on a bridge for one hour, the labor and equipment cost for removing graffiti can be calculated as \((1*2*36.13) + (1*1*50) = 122.25\) and it can be converted for one square foot as \(122.25/28.9 = 4.23\). As per Caltrans, the average lane closure cost while removing graffiti is $1,070. Then, the lane closure cost per square foot can be calculated as: \(1,070/28.9 = 37.02\). Therefore, the total removal costs for one square foot of graffiti is calculated as the sum of the paint cost, labor & equipment cost and lane closure cost, that is: \(2 + 4.23 + 37.02 = 43.25\).

The cost for removing one square foot of graffiti for the bridges with pedestrian fencing was calculated in the same way as for the bridges without fencing. The only difference is the average area of the graffiti without fencing which is 4.76. Then, the cost
for lane closure per square foot for removing graffiti without pedestrian can be derived as: $1,070/4.76 = $224.79. The total cost for removing one square foot of graffiti is: $2.00 + $4.23 + $224.79 = $231.02.

The benefits in monetary terms can be calculated as the difference between graffiti removal cost without fencing and with fencing. From the inventory database, the average number of graffiti for bridges without and with fencing is 3.95 and 0.46, respectively. Multiplying these number of graffiti by their unit cost, the benefit can be calculated as: 3.95*($43.25*28.9) - 0.46*($231.02*4.76) = $4431.87 per one year. Using the same uniform series present worth factor as before 10.675, the benefits over the 25 years can be derived as $47,309.26. Then, benefit and cost ratio can be calculated as $47,309.26 / $11,912.41 = 3.97. The ratio being greater than one indicates that fencing is a cost effective countermeasure for mitigating graffiti on bridges.

Sensitivity Analysis:

From the calculation above it can be seen that the benefit and cost ratio varies with several factors such as the effectiveness of the pedestrian fencing in terms of the number of graffiti reduced and the interest rate. In the cost-benefit analysis discussed above, the number of graffiti cases on a bridge when there was fencing was considered as 0.46, which is about 90% reduction comparing with the case when there is no pedestrian fencing. If this percentage is varied, the cost and benefit ratio would be changed correspondingly. From Figure 36 it can be seen that pedestrian fencing would not be cost effective if the percentage of the reduction is less than ten, for which the corresponding number of graffiti is 0.92 in a year. In other words, this countermeasure would be cost effective as long as the number of graffiti is reduced to about once in a year on a certain
bridge. Based on the experience from NDOT, having the number of graffiti reduced by 90% is a regular objective that can be achieved for a new countermeasure. Thus, pedestrian fencing seems a cost-effective considering the possible reduction of graffiti occurrences.

To see the sensitivity of the cost effectiveness of the pedestrian fencing, the benefit and cost ratio was also calculated for different interest rate. From Figure 37 it can be found that the benefit and cost ratio decreases as the interest rate increases. It would still be kept in the level above one even for the high interest rate of 14. Based on the sensitivity analysis for these two factors it can be seen that the pedestrian fencing presents itself a countermeasure with high likelihood to bring benefits by reducing the graffiti occurrences.

![Figure 36. The B/C Ratio versus the Effectiveness of the Pedestrian Fencing on Bridges](image-url)
7.2 Chain Link Fence on the Corners of the Bridge

Chain link fence on the corners of the bridge can be a good preventive measure for accessing taggers to the bridge retaining walls and thus graffiti on these walls can be reduced. The access point to the retaining walls, if there is no chain link fence is presented in Figure 38.

Figure 37. Benefit and Cost Ratio versus Interest Rate for Pedestrian Fencing

Figure 38. Access Point to Retaining walls, If No Corner Fence
(Photo Taken by Research Team in 2007)
Costs:

The costs incurred for having chainlike fences around a bridge are the capital cost to buy the fence, the installation cost, and the maintenance costs for repairing the fence throughout its lifetime. The capital cost to buy the chain link fence is $1.2 per square feet (Lowe’s Website, 2008) Assuming the chain link fence of 25 feet long and 5.8 feet high is installed on the four corners of the bridge in Las Vegas and Reno area, the capital cost of the fence is calculated as: $1.2*25*5.8*4 = $696. Assuming the installation cost per square foot is $6.2, the same as that of the pedestrian fencing, the total installation cost is calculated as: $6.2*25*5.8*4 = $3,596. With the same assumption on the maintenance costs $1,588.41 for the pedestrian fence throughout the lifetime of 25 years, the net present value of the total costs are calculated as = $696 + $3,596 + $1588.41 = $5,880.41.

Benefits:

The benefit of the chain link fence on the corners of the bridge is calculated as the difference between the graffiti removal costs before and after installing it. The paint cost for removing graffiti is assumed $2 per square foot area, the same as the number assumed for pedestrian fence. From the inventory data collected, it was observed that the average number of graffiti cases on the retaining wall, while there was no chain link fence on the corners of the bridge, is 0.73 per year, each with an average area of 3.43 square feet. Assuming that there is 80% reduction in the number of graffiti cases, the number of graffiti cases comes to 0.2*0.73 = 0.15, each with an area of 3.43 square feet. As the case of pedestrian fence, the labor and equipment costs are assumed to be $122.25, which can be converted as $122.25/3.43 = $35.64 per square foot. In a similar way, the lane closure cost can be calculated as $1070/3.43 = $311.95 per square foot. Thus the total removal
cost per square foot area is calculated as: $2 + $35.64 + $311.95 = $349.60. This is assumed the same with and without chain link fence installed. Therefore, the difference between the total removal costs per bridge without and with installing chain link fence on the corners of the bridge can be calculated as $349.6 = $349.6*3.43*0.73 - $349.6*3.43*0.15 = $700.28, which is the annual benefit of installing chain link fence to a bridge. With the same interest rates of 8%, the uniform series present worth factor is 10.67. The converted benefits of installing chain link fence over the lifetime is $700.28*10.67 = $7,475.37. Thus, the benefit cost ratio can be calculated as $7,475.37/ $5,880.41= 0.786, which is greater than one. Therefore, installing chain link fence on the corners of the bridge is a cost-effective technique.

From the analysis above it can be found that the length of the chain link fence is critical in determining the benefit and cost ratio. Thus, the value of length was varied from 25 feet to 200 feet at each corner. The total length of the chain link fence was changed from 100 feet to 800 feet considering there are four corners for a bridge to be installed with the fence. Figure 39 indicates that the benefit and cost ratio drops significantly when the total length is short. As the total length increases, the benefit with the total 80% reduction of graffiti would be balanced out. Since the benefit and cost ratio decreases sharply when the length starts to increase at a small value, the countermeasure is sensitive to its length.
The sensitivity of the benefit and cost ratio was also analyzed for varying the interest rate. Figure 40 demonstrates that the benefit and cost ratio reduces close to one when the interest rate is about 14%. This result indicates that the chain link fence with short length is quite resilient to the change of interest rate.

Figure 39. The Change of Benefit and Cost Ratio over the Total Length of Chain Link Fence

Figure 40. Benefit and Cost Ratio over different Interest Rate for Chain Link Fence
7.3 Rat Guards/Graffiti Guards

Overhead signs are one of the highway infrastructures suffering from graffiti vandals in Las Vegas. While cleaning graffiti on these signs, the signs lose their reflectivity. The signs have to be replaced, if they are attacked by the taggers multiple number of times. To remove graffiti from the signs, the removal crew needs graffiti removal trucks. The crew also needs to close a traffic lane, which costs thousands of dollars. To avoid these removal costs, Rat Guard is viewed as the effective tool preventing graffiti on traffic signs.

Currently, NDOT has its own staff to manufacture rat guard, going through the process from purchasing the needed materials to finishing up the product. Basically, rat guards are the graffiti barriers made of metal sheets that can be arranged on the sign poles to prevent access of taggers to the overhead signs. The guards are prepared in a way to minimize all possibilities that anyone can grab hold of the guard and pull himself up.

Rat guard Capital, Installation and Maintenance Costs:

The capital cost is for purchasing materials such as metal plates. It also includes the labor cost for manufacturing the guard with the materials purchased. With the rat guard built, it will be mounted on traffic sign poles, which is the actual installation process. According to NDOT, the total costs of the manufacturing and installation is $150. The mounted rat guard may be subject to damages due to nature causes such as wind and rain, and man-made causes such as vandalism by taggers. The costs to cover these damages were estimated as $50 per year. This annual maintenance cost can be used to derive the total maintenance cost over the five year life time as $50 * 3.99 = $199.63, where 3.99 is
the uniform series present worth factor. The total capital, installation and maintenance costs are calculated as $150 + 199.63 = $349.64.

Graffiti removal costs:

From the NDOT experience, removing graffiti per square foot from a sign would consume one quarter of a can priced at $15.00. Then, the average cost of removing graffiti per square foot from one sign is $15/4 = $3.75. As per the field observations, the average area of one graffiti case on the overhead signs is four square foot. Therefore, the average cost of removing graffiti of four square feet on a particular sign can be calculated as: ($3.75*4) = $15.00. Based on field observations, the number of graffiti cases on an overhead sign, while there is no rat guard, is estimated as 2.4 per year. Therefore, the total cost for removing graffiti a year is calculated as: 2.4*15 = $36. To remove graffiti from the overhead signs, there is a need for labor and equipment such as graffiti removal trucks, which was assumed as $100 per graffiti case and it comes to ($100*2.4) = $240.00 per year. While removing graffiti from the traffic sign, a traffic lane has to be closed in non-peak hours. According to Caltrans, like the case for fencing, the approximate lane closure cost is $1,070. For the total of 2.4 graffiti cases a year, the total lane closure cost in one year is $1070*2.4 = $2,568. Therefore, the total graffiti removal costs on the overhead signs without rat guards are calculated as the sum of the capital, labor, and lane closure costs that is: $36 + $240 + $2,568 = $2,844 per year. The costs over the five years can then be calculated as $11,355.27

According to the experience of maintenance crew in the NDOT District 1, the number of graffiti was reduced by 90% on the overhead signs, while rat guard is installed. Thus, the number of graffiti cases on the overhead signs per year with rat guard
installed was estimated as: (0.1*2.4) = 0.24. With this number, the total graffiti removal cost on overhead signs with rat guard is derived as $284.40. The cost over the life time for a rat guard is derived as $1,135.53.

Cost and Benefit Ratio:

The difference between the costs with and without the installation of rat guard can then be calculated as the benefits incurred: $11,355.27 - $1,135.53 = $10,219.74. Considering the cost for having the rat guard installed, the benefit and cost ratio can be derived as 10,219.74/349.64 = 29.22, which is much greater than one. This result indicates that rat guards are cost effective in preventing graffiti on overhead signs.

Sensitivity Analysis:

In the cost-benefit analysis discussed above, the frequency of graffiti when there is no rat guard may vary significantly dependent upon the location where a traffic sign is installed. In the calculation of the benefits above, it is assumed that the frequency of graffiti with no rat guard is 2.4 per year, equivalent to 12 graffiti cases for five year. This frequency was varied from one to 12 graffiti cases in five years. As indicated in Figure 41 that the benefit would be greater than the cost even for the case when the number of graffiti cases is less than one in five years. The current condition is that the number of graffiti is 12 in five years, which is far greater than the minimum number of graffiti making the rat guard cost beneficial. This result indicates that rat guard is very commendable as for a graffiti countermeasure. The main reason for rat guard to be relatively high cost effective is the low capital cost, installation, and maintenance cost for it.
Sign Replacement Costs:

Sometimes the signs have to be replaced, if they are attacked multiple times. Assuming a sign has to be replaced, if it is attacked three times in the same place, the number of sign replacements per year can be calculated as: 2.4/3 = 0.8. The replacement cost per one traffic signs was assumed as $400. Therefore, replacement cost for one year is 400*0.8 = $320 and the cost over five years is derived as $1,276.8 when there is no rat guard installed. If a rat guard is installed, the cost for five years becomes $127.58. Then, by adding the sign replacement cost on the top of the costs when the sign replacement is not considered, the total removal/replacement costs on a sign are $11,355.27 + $1276.8 = $12,632.07 and $1,135.53 + $127.58 = $1263.21, respectively, for the case of without and with rat guard. Therefore, the corresponding benefit is calculated as: $12,632.07- $1263.21 = $11,368.86. The corresponding benefit and cost ratio is $11,368.86/ $349.64 = 32.51, which is also greater than one. It addition, this ratio is even greater than that
when the sign replacement is not considered. Because the cost for replacing sign would also be reduced if less number of graffiti cases occurs.

![Graph showing benefit and cost ratio versus interest rate for Rat Guard.](image)

**Figure 42. Benefit and Cost Ratio versus Interest Rate for Rat Guard**

To evaluate the sensitivity of the rat guard with regard to the interest rate, the benefit and cost ratio was calculated for different interest rates. The results are presented in Figure 42. It can be seen that the benefit and cost ratio does not change dramatically with the interest rate, which implies that Rat Guard is not sensitive to interest rate.

In this study, it was assumed that costs incurred to countermeasure of graffiti shields are the same as those for rat guard. The same amount of benefits for rat guard can be achieved by graffiti shields. Thus, the results of the analysis for graffiti shield would be the same as for rat guards. In reality, these two countermeasures are different in terms of the locations of traffic signs on which they can be installed. For example, rat guard may be more suitable to traffic signs that have poles to support it. It cannot be used for
the traffic signs that are mounted on facilities such as bridges. In this case, protesting the sign becomes the sole objective.

7.4 Security Cameras

Suppose that a camera is installed on the back of a sound wall. It is infrared based to detect graffiti activities. After the detection of a graffiti activity, pictures would be taken automatically. The pictures taken in a certain period of time like a week will be downloaded all together through wireless communications. According to sources from the City of Las Vegas, the capital cost for purchasing such a system was $6,000, and the installation cost is assumed $200. No operation and maintenance costs were assumed for the camera system as the cameras have self-battery systems and have a five-year warranty. Note that there might be labor and equipment costs incurred in taking down and reinstalling the camera when the camera is found malfunction. These costs were not included in this study.

The benefits of installing a camera on the back of the sound wall in a graffiti-prone area will be in terms of savings in the graffiti removal costs. This can be expressed as the difference between graffiti removal costs before installing cameras and after installing cameras. As per the City of Las Vegas, in a typical location where the occurrence of graffiti vandalism is high, the cost of removing graffiti is $1,600/month that includes costs for materials, labor and equipment. Because there is no need of closing traffic lane when removing graffiti on the back of the sound walls, the cost for lane closure was not included in calculation. This cost of $1,600 per month comes to $19,200 a year. For the five year period, the cost on graffiti removal can be calculated as $76,660.
In the calculation, a uniform removal cost throughout the lifespan of the camera and 8% interest rates to the present value are assumed. After the installation of a camera, the removal cost in this case was reduced to approximately $50 a month. The removal cost for a year can then be calculated as $600. The present value of the costs to remove graffiti for the five year can be derived as $2,395.8. Then, the benefit for installing cameras can be derived as $76,660 - $2,395 = $74,264. Thus, the benefit and cost ratio of security cameras can be calculated as: $74,269.8/$6,200 = 11.97, which is greater than one.

Note that camera can be installed for many facilities such as sound walls and bridges. In this calculation, only one camera was assumed for a segment of sound wall with a range that can be covered by the camera. The calculation would vary with the frequency of the graffiti in the range covered by the camera. In other words, an area around a sound wall or bridge may need more than one camera to cover. The frequency of graffiti on the ranges covered by these cameras would be different. Then, different benefit and cost ratio may be resulted.

Sensitivity Analysis

There are many factors that influence the benefit and cost ratio, which includes the number of graffiti in a covered area before the installation of a camera, the reduction of the occurrence of graffiti after the installation of the camera, the maintenance costs for the camera that may be caused by malfunction of the camera or vandalism, the capital cost for purchasing the camera, and the interest rate used in the calculation. In this study, only two factors were considered: the reduction of the occurrence of graffiti after the installation of a camera and the interest rate. The results are presented in Figures 43 and 44, respectively.
In evaluating the impact of the effectiveness of the camera in terms of the reduction of graffiti, the graffiti removal cost before the installation of the camera is fixed at $1,600 per month. The reduction rate is varied from zero to 100. From Figure 41 it can be seen that the benefit cannot balance out the cost of having the camera when the cost for removing graffiti is reduced less than 10%. It can be expected that reducing the removing cost by 10% is not a difficult objective to achieve, which make this countermeasure is more appealing.

Figure 43. Benefit and Cost Ratio versus Graffiti Removal Cost Reduction with Camera Installed
In the calculation of the benefit and cost ratio, the interest rate was changed from 4% to 12%. From Figure 42, it can be found the corresponding benefit and cost ratio changed from 11.92 to 12.02, which is very small. Based on the analysis for the two influencing factors, it can be concluded that camera is a cost effective countermeasure for graffiti.

7.5 Anti-Graffiti Coatings

In this study, it is the non-sacrificial coating that was considered for cost and benefit analysis. Sacrificial coatings were not considered because they are more expensive than non-sacrificial coatings. In the analysis below it is assumed that the non-sacrificial coatings are applied to sound walls.

The total costs incurred for a sound wall with non-sacrificial anti-graffiti coatings applied include the capital costs of the anti-graffiti coatings, costs for applying the coatings, and maintaining costs such as lane closure costs and graffiti removal costs. According to NDOT, the cost of non-sacrificial coatings per gallon is about $52 and it
NDOT’s experience indicates that about half gallon of coatings is required for applying to a one-square-foot area, and it varies for different surface type and texture. In the calculation, capital cost to purchase non-sacrificial coating for one-square-foot area is derived as $52*0.5 = $26. For a sound wall of one mile long and 7.5 feet high, i.e., 39,600 square feet area, the capital cost to apply anti-graffiti coatings on this sound wall is: (39,600*$26) = $1,029,600. To apply anti-graffiti coatings to the surface of sound wall, manpower and equipment is needed. According to Caltrans, the installation cost including manpower cost is around $680. While applying anti-graffiti coatings, a traffic lane need to be closed, which cost around $1,070. Thus the total cost of applying anti-graffiti coatings on a sound wall is the sum of capital, installation, operation, and maintenance costs that is: $1,029,600 + $680 + $1,070 = $10,31,350.

The benefits of applying anti-graffiti coatings on a sound wall will be in terms of savings in graffiti removal costs. This savings can be viewed as the difference between graffiti removal costs on the sound walls with and without applying anti-graffiti coatings. The removal of graffiti on sound wall with non-sacrificial coating doesn’t need any paint because graffiti can be rubbed off. It was indicated by the NDOT maintenance crew that the rubbing takes a lot of effort and time consuming. It is assumed that it takes five minutes to rub off one square foot of graffiti. The unit cost for one minute is $0.6 for a person with annual salary of $50,000 with 0.5 fringe and benefit. As per the inventory data collected, the average area of graffiti on one sound wall segment with no anti-graffiti coatings applied is 12.26 square feet. This average area is assumed the same as the case with coatings and was used in the calculation. Then, the labor cost for removing the
graffiti is: $0.6 \times 5 \times 12.26 = $36. In addition to the labor cost, the equipment cost to remove graffiti on a sound wall was assumed as $60. A lane has to be closed while removing the graffiti on the sound wall, which costs around $1,070. Thus, the total graffiti removal costs on a sound wall with coatings applied are calculated as: $36.9 + 60 + 1,070 = $1,166.91.

According to NDOT, the cost of graffiti removal, where anti-graffiti coatings are not applied, is $2 for the paint used for one square foot area. As mentioned earlier, according to inventory data, the average area of graffiti on a sound wall with no anti-graffiti coatings applied is 12.26 square feet. Thus, the capital cost of graffiti removal on a sound wall will be $12.26 \times $2 = $24.52 per graffiti. It is assumed that one graffiti case appears on this sound wall (one mile long and 7.5 feet high). Then, the annual capital cost can be derived as: $24.52 \times 1 = $24.52. For a person with the same salary and fringe benefit assumed above, the labor cost is calculated as $0.6 \times 2 \times 12.26 = $14.76 per graffiti, assuming that it takes two minutes to clean one graffiti. Because only one graffiti is assumed for this sound wall in a year, the annual labor cost is also $14.76. It is further assumed that the equipment cost for removing graffiti on a sound wall without anti-graffiti coatings applied is $60. According to Caltrans, the traffic lane closure cost, while removing graffiti on a sound wall is $1,070. From the above costs, the total cost of graffiti removal on a sound wall with no anti-graffiti coatings applied is the sum of capital, labor and equipment cost and lane closure cost, i.e., $24.52 + 14.76 + 60 + 1,070 = $1,169.28 per year. It can be seen that the cost for removing graffiti with coatings is on the same level as that without. The reason is that rubbing off graffiti takes longer time than painting over and at the same time the paint cost is relatively low, which means that
little benefit can be gained for applying anti-graffiti coatings to sound walls. It can be seen that the costs calculated for applying coatings to the sound walls is a huge amount. Additionally considering this cost, anti-graffiti coatings are not cost-effective measures for sound walls. Note that this cost for applying coatings would vary with the size of sound wall, primarily the length of sound wall. This cost would be reduced if a shorter sound wall is considered.

But these coatings can be recommended to structures like sculptures, as there won't be any damage to the sculpture for the protection of coatings when graffiti happens. If no such coatings are applied to this kind of structures, the property damage of the sculpture in monetary terms will be much higher and it would be more than the cost of the coatings, as the sculpture has to be replaced.

Suppose, a sculpture with 216 (6*6*6) square feet is considered for this study, which costs around $20,000. The cost of applying anti-graffiti coatings will be 216*$16 = $5,616. Considering the same installation and lane closures costs in the above case, the total cost for applying anti-graffiti coatings is $5,616 + $680 + $1,070 = $7,366. Assuming the same graffiti removal cost, while anti-graffiti coatings are applied, the total costs in this case is $7,366 + $1,166.91 = $8,532.91. If the sculpture has not treated with anti-graffiti coatings, the graffiti on it cannot be removed without damaging it. In this case sculpture has to be replaced, which costs $20,000. So, the benefit of applying anti-graffiti coatings can be viewed as the sculpture cost that is $20,000. Therefore, the benefit and cost ratio is calculated as: $20,000/$8,532.91 = 2.34, which is greater than one. This result indicates that anti-graffiti coatings are cost-effective in the case of sculptures of high value.
7.6 Landscaping to Sound Walls

It was observed from literature that landscaping to sound walls is a good preventive measure for graffiti on sound walls. The landscaping might be in different forms such as vines, bushes and rock. The costs and benefits of landscaping were discussed below.

Assuming the same graffiti removal costs mentioned in the above section, if there is no landscaping to the sound wall, the annual graffiti removal costs $1,169.28, the graffiti removal costs over the 15 years lifetime of landscaping will be $1,169.28*8.55 = $10,008.46, where 8.55 is the uniform series present worth factor assuming an 8% interest rate. Assuming that graffiti will be completely reduced on the sound walls, if the landscaping is provided, the project will be cost effective if the cost of the project doesn’t exceed $10,008.46. As the actual costs of the landscaping project are not available to this study, the benefit and cost ratio was not provided in this study.

7.7 Electronic Spectrometers

While removing graffiti on a surface by using ‘paint over’ technique, it is preferred to use the paint with the color that exactly matches with the base color of the surface for visual quality. If the paint color doesn’t match with the base color of the surface, the paint will remain as the patches of different colors on the surface, which will cause visual degradation and social and culture problems. Spectrometers are the color matching instruments, which can be used for matching the paint color with the base color of the surface. They are helpful in maintaining the consistency in color for the structure.
after painting over graffiti, thus improving the visual performance of the surface and upgrade the social and culture environments of a community.

Spectrometers are the electronic machines that costs around $5,000 a piece and will have a five-year warranty. They need software for color matching process that costs around $40,000, which is a one-time investment. The upgrades on the software will be free. The benefits of using spectrometers may not be readily quantifiable in monetary terms. In this study, they were evaluated in a qualitative way from the perspective of visual and social impacts.

Visual Impacts of Patches of Paint over of Graffiti:

The visual performance measures taken in this study are: (1) color for compatibility; (2) continuity; (3) visual dominance; and (4) visual quality measure unity (Sinha and Labi 2007). Among these four measures, color compatibility is defined as consistence between the paint color and base color. The more the rating score this measure receives, the more the visual performance will be. Continuity refers to the uninterrupted flow of the surface without any patches. Visual dominance indicates the dominance of the graffiti patches on the whole surface. Less visual dominance leads to better visual performance. The visual quality measure unity is referred to the degree to which the whole surface is coherent. All these four measures can be rated from 1 to 10 scale ratings and their weightings in overall visual performance can be measured in the scale of 0 to 1. Considering two cases, one with the use of spectrometers and another is without. Table 20 presents the rating scores and weightings of all the four visual performance measures. It can be seen from the table that the score on visual dominance for spectrometers use is lower than that for the case when spectrometers are not used. It is
because the multiple colors of patches would dominate the visual effects of the surrounding when colors are not matched with spectrometers.

Table 20: Rating Scores of Visual Performance Measures

<table>
<thead>
<tr>
<th></th>
<th>Compatibility</th>
<th>Continuity</th>
<th>Unity</th>
<th>Visual Dominance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrometers used</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>No spectrometers used</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Weightings</td>
<td>0.4</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Based on the visual rating scores, the visual performance of the two cases can be calculated as:

Use Spectrometers: \[ (0.4 \times 8) + (0.2 \times 6) + (0.2 \times 7) + (0.2 \times 4) \] = 6.6

Not Use Spectrometers: \[ (0.4 \times 2) + (0.2 \times 1) + (0.2 \times 3) + (0.2 \times 8) \] = 3.2

From the above calculations, it can be observed that visual performance of using spectrometers is more than double that of not using spectrometers. This indicates that using spectrometers will enhance the visual performance of the surface of highway infrastructures.

Social and Cultural Impacts:

“Graffiti Vandalism”, including the removed patches of graffiti, has an adverse social impact on the society in direct and indirect ways. The direct impact includes property damage, the value of community diminishing. An example for property damage is tag using certain chemical on a fine sculpture on roadside. The tagged color may penetrate into inner layers of surface, and thus may not be removed by regular removal techniques such as water or sand blaster. This sculpture may have to be replaced. For a
community with many facilities such as sound walls, typically the back of sound walls, tagged, an impression would be created that the community is having crime related activities and is unsafe. The residents may not want to stay in the same location and they may be willing to relocate. The physical, emotional and financial stresses of moving can be overwhelming for families and individuals. The indirect impact of graffiti or the painted over image is that some children and youth may be attracted and encouraged to create one. In this way, there may be chance to increase the criminal mentalities in the children.

Social and cultural impacts can be measured differently in scale, severity or intensity depending up on the nature of the community or location. Examples of these measures are the number of properties damaged by graffiti, the number of residents moving out a community, and the change of incomes in community chronically tagged. These measures vary with the population size, income level of the population, cultural resources of the communities, the government policies on the taggers, types of punishments, law enforcement, coordination between public, police, schools and other agencies, crime rate of the community, frequency of vandalism and the types of structures affected.

7.8 Graffiti Tracker

Graffiti Tracker is a web-based software system that gives city officials and law enforcement administrative the tools necessary to reduce graffiti vandalism. With a graffiti submitted from an agency, it will be analyzed by graffiti analysts in the company owning the software Graffiti Tracker. In the analysis, the submitted graffiti will first be
analyzed visually to determine whether the graffiti is a tagging or gang-graffiti. They then translate the graffiti in a format (characterizing the graffiti by certain parameters) that is readable by Graffiti Tracker program. Then the Tracker will display the location of this graffiti with others that have similar characteristics on a map. This intelligence would be useful in tracking the taggers.

To get the intelligence, an agency has to pay one dollar for each graffiti case. If 60,000 graffiti cases are found by an agency in a year, this agency has to upload these 60,000 to the Tracker system and pay $60,000 to the company owning the system. According to Clark County, it is not difficult for an experienced anti-graffiti staff to find the same intelligence from the Tracker, which makes this system less valuable to the anti-graffiti team.

7.9 Electronic Database

Maintaining electronic database of graffiti is a good resource for finding the locations, where specific measures need to be improved for mitigating and preventing graffiti. The data can be shared among different agencies working against graffiti so that they can work together. This data may include the graffiti name and type, location, surface type, removal method used and removal costs etc. The in-house removal team can collect this data, while they remove graffiti. So, it won’t cost additional amount to maintain the electronic database. The benefits of maintaining database include scheduling daily operations, finding statistics of the graffiti and removal costs and catching taggers by providing extra surveillance.
CHAPTER 8

RECOMMENDATIONS FOR IMPLEMENTATION

Pedestrian fencing on bridges has found effective in reducing graffiti in NDOT. It has also been adopted in other states such as Arizona and Virginia. The cost and benefit analysis in this study indicates that it is very cost effective in preventing graffiti. Thus, it is recommended for NDOT to adopt fencing at bridges that have potential place for graffiti.

Chain link fence on the corners of the bridge was found to be a good solution in literature in mitigating graffiti on retaining walls of the bridge. The cost and benefit analysis provided in this study shows that it is a cost effective graffiti preventive measure. The cost and benefit analysis indicates that chain link fence is cost effective only when the length of the chain link is relative short. So, it is recommended to NDOT to implement chain link fence with the consideration of its length. Note that, pedestrian fencing on the top of the bridge and chain link fence on the corners of the bridge are suggested to be implemented at the same time. Failing to implement any one of the two fences would allow the taggers to find the ways to tag a bridge.

In addition, chain link fence on both ends of sound walls is recommended. This fence joins the end of sound wall to the surrounding residential wall, so that the taggers do not have the chance to access to the back of the sound wall. Most of the sound walls in Reno are provided with this fencing and are found successful in mitigating graffiti. As
taggers may break this fence, strong fence is recommended in this location. The length and height of the fence should be chosen dependent on the location.

NDOT has been adopting rat guards and graffiti shields for preventing traffic signs from graffiti. They have been found adopted in other states such as California. The cost and benefit analysis in this study shows that they are very cost effective primarily due to the low cost for manufacturing the rat guard. One problem found for these countermeasures is that taggers may step on top of the metal plate from nearby facilities such as sound walls. Thus, there is a need to inform the design division of such an issue related to graffiti. Such sections of facilities like sound walls close to the traffic sign need to be built with specification of a distance from traffic signs. For the existing location, possibility of modifying the concerned sections should be investigated.

Security cameras have been used in some cities and state DOTs for anti-graffiti at the hot spots of graffiti on different highway infrastructures such as bridges and sound walls. This has been found from literature review, visits to some cities and state DOTs, and survey to state DOT. The cost and benefit analysis conducted in this study shows that security cameras are cost effective in general conditions. They may not be cost effective if the system fails at high frequency or the reduction in graffiti is small. Purchasing reliable camera system seems very important. There are other issues that are worthwhile for a discussion. First, what functions of the camera system should be used need to be determined based on test results. For example, the system can be triggered to announce warnings to taggers detected by the system. This function may have the deterrent effects. On the other hand, it may cause taggers to vandal the system making it fail. The system can also be set up for alerting relevant agencies of detected graffiti activities.
alerted agencies may even respond to the alerts immediately to the scenes to catch the taggers. The false alarm of the camera system with such a function would be a very critical issue. For each response, there would be a tradeoff between catching taggers on site and wasting the efforts to the site. It was also found that the system produce many pictures for false alarms which would jam the electronic storage space. This would increase the times for the relevant staffs to maintain the system in working conditions.

The other types of cameras are video surveillance cameras, which record the spot when there is motion detected. These cameras are adopted by the Parks Department in Los Angeles. The costs of these cameras are much higher than the infrared cameras mentioned above. Moreover, additional staff may be needed to monitor the video, which would add some cost to the system. These cameras are not recommended in general locations but in the places where graffiti occurs more frequently and the location has more valuable property. Some states are planning to use traffic cameras for graffiti surveillance. But there are several issues such as the distance of location of the camera from the structure expected to attack by the vandals, the multi functionality of the camera and the distance covered by the camera. Moreover, the function of graffiti surveillance by these cameras should not cause any obstruction to primary purpose of traffic surveillance. Note that these cameras cover only the roadside of the structures. The rear side locations such as back of sound wall will not be covered. The angle focused by the camera is also an important factor to be considered. If the camera is focused in an angle to cover the graffiti vandals, it may not cover the traffic on the roads completely. All these factors have to be considered before using the traffic cameras for graffiti surveillance.
Coatings, particularly the non-sacrificial coating, have been evaluated in this study as not cost effective for infrastructure of large size like a whole segment of sound wall. However, it would be cost effective for a small sized infrastructure like sculpture or a well-designed picture on the retaining wall around a bridge.

Spectrometers are starting to be adopted by more cities for anti-graffiti in recent years. There are also a few state DOTs using it. The cost and benefit evaluation in this study indicates that there are great potential benefits for having these devices in improving visual and social impacts by graffiti. Even though the cost for the needed software of spectrometer is relatively high, it may be worthy to try it out in NDOT. To reduce the cost of the software, developing the software internally can be tried.

To have an electronic database is recommended for NDOT since it is not difficult to develop and maintain such a system. It can provide many benefits such as producing statistics of graffiti in space and time that can help trace down graffiti and catch taggers. The system can also help schedule maintenance activities. The expenditures on anti-graffiti can also be produced from the system easily, which would be important information for financial decision to be made by the state officials.

Cooperative working with other anti-graffiti agencies such as cities, counties, law enforcement, schools, neighborhood communities and other private agencies is suggested for NDOT. This task is not expensive but could be helpful in mitigating graffiti.

As summary, all the above-recommended countermeasures are shown in Table 21 for the four significant highway structures: bridges, sound walls, retaining walls and traffic signs. In the table N/A indicates not applicable.
Table 21: Facility Based Countermeasures

<table>
<thead>
<tr>
<th></th>
<th>Bridge</th>
<th>Sound wall</th>
<th>Retaining wall</th>
<th>Traffic Sign</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Fence</td>
<td>Top</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>4.04</td>
</tr>
<tr>
<td>Chain Link Fence</td>
<td>Corner</td>
<td>Ends</td>
<td>Around</td>
<td>N/A</td>
<td>1.26</td>
</tr>
<tr>
<td>Rat Guards</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>32.51</td>
</tr>
<tr>
<td>Graffiti Shields</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>32.51</td>
</tr>
<tr>
<td>Anti-Graffiti Coatings</td>
<td>Sculptures on bridges</td>
<td>Short, drawing on wall</td>
<td>Drawings on walls</td>
<td>N/A</td>
<td>2.34 (sculpture)</td>
</tr>
<tr>
<td>Security Cameras</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>11.97</td>
</tr>
<tr>
<td>Spectrometers</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Database</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Educational Awareness, Law Enforcement, Neighborhood Clean up</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

Among these countermeasures, rat guards and graffiti shields and cameras are highly recommended because of their high benefit and cost ratios. Developing database for graffiti is necessary for management perspective and thus is also highly recommended. Pedestrian fencing and chain link fence are the next. Even spectrometers may be involved high cost, it is also worthwhile to recommend it for a try with high priority. Coatings have very limited applications but would be useful for these applications.
APPENDIX I

GRAFFITI COLOR BOOK FROM CITY OF PHOENIX IN ARIZONA
Useful tools to keep your neighborhood free of graffiti.
OH NO! Someone has painted graffiti on our house.
More, let's call the Graffiti Busters Hotline!
(602) 495-7014

CH NO! Graffiti Buster is here!

Can we help?

Yes you can help!
I've brought everything you will need to remove the graffiti!
YEAH We did it! The graffiti is removed.
WE make a great team!
Graffiti Buster says, "Thank you for being a good neighbor!"
For more information on graffiti removal, visit our web site at http://phoenix.gov/NBHDGMS/grafbust.html
Can you show Graffiti Buster the way to your house?
"To preserve and improve the physical, social, and economic health of Phoenix neighborhoods, support neighborhood self-reliance, and enhance the quality of life for residents through community-based problem solving, neighborhood-oriented services, and public-service cooperation."

QUICK GRAFFITI REFERENCE

Graffiti Busters 24-Hour Removal Hotline
(602) 495-7010

Contact Local Law Enforcement
(602) 495-7880

Graffiti In Progress
(602) 495-7010

Send site location using email: graffiti.busters@phoenix.gov

Free paint for graffiti removal
(602) 495-8523

Tasks for neighborhood clean-up
(602) 495-0223

Need a paint-sprayer? (Training provided)
(602) 495-9332

Request removal access to property (secured)
(602) 267-7880

Vandal-catch reward program
(602) 262-7171

Would you like to continue and help remove graffiti? Contact Make a Difference at 602/267-7777.

If your property is compromised by graffiti, take a digital photo and e-mail a snapshot with (first name, last name) as your subject.

Crime Prevention Through Environmental Design (CPTED)
For additional information, contact your local Police Precinct.

For a copy of this publication in an alternate format or for reasonable accommodations contact the Neighborhood Services Department 2421 W. Washington, Phoenix, AZ 85001
(602) 264-8680, TTY (602) 267-4951, deaf

For more information on what is possible in Spanish

City of Phoenix
E-mail: graffiti.busters@phoenix.gov
APPENDIX II

ANTI-GRAFFITI BROCHURES
Helping to Keep Our Neighborhoods Graffiti Free
Impulse Year
Neighborhood Today

The Old Model has proved necessary to be broken and adjusted for the newly emerging world. Structural restraints are only one aspect of the transforming process. The new model must: 1) relate to the environment, 2) emphasize needs, 3) develop strategies that will allow the community to withstand change, and 4) foster the development of new ideas. Educational programs and activities are necessary to promote these changes.
Quick Graffiti Reference

Graffiti Busters
24 Hour Removal Busting... 602 445 7004
Graffiti Removal Program... 602 445 6420

Verizon and AT&T Cellular
Phone Users call toll-free... 1 844 463

Graffiti Removal Catching
Bureau Program... 602 262 7327

Tools for home owner/first point
For graffiti removal... 602 495 0328

Print Sprayer on Wheels... 602 495 0328

Graffiti in Progress... 911

Retail (not access to spray paint)... 602 767 7844

Email... graffiti.busters@phoenix.gov
Fax... 602 495 0445

Internet... www.phoenix.gov/
        REHAB/GRADS/graffiti.html
DON'T GET FINED.
DON'T POST SIGNS.

City of Phantom

No person posting signs on this pole is subject to a $5.00 fine (Sec. 3-6-10)
You've seen the signs... signs mounted on a utility pole insuring weights, fire stations, or legal aid signs. They're legally advertising public utilitites or services. Signs on the street at the end of an intersection or on the sidewalk also guide pedestrians around the corner. Signs along the roadway can give directions to a turn, a hotel, a complex, or a new housing development.

All these signs are very common and have always been "NO STANDING"

The city of Phoenix has a street sign ordinance that includes severe penalties for anyone violating the ordinance. Posting your sign without permission is illegal and dangerous.

WHY DOES PHOENIX HAVE A SIGN ORDINANCE AND PROHIBITS SIGNS PLACED IN THE RIGHT-OF-WAY?

The purpose of this sign ordinance is to provide for street and sidewalk maintenance in an unobstructed manner throughout the city. Illegal signs can be hazardous to pedestrians and vehicular traffic by both blocking the view of recreation areas from the view of motorists. Signs on sidewalks or bike lanes can cause pedestrians into traffic. Signatories must ensure it with all drivers to see into intersections.

Signs are an eyesore; they can become paper pulp in the rain, adding to the blight in many areas.

WHAT IS A RIGHT-OF-WAY?

The right-of-way is a roadway throughout the city of Phoenix. As a resident of a city, it contains streets, avenues, roads, minor streets, underpasses, and approved shoulder or street signs. Private property is generally not included within the right-of-way. However, it includes residential and private property throughout Phoenix.

Businesses must determine the right-of-way to attract customers and advertise by posting signs on private property. As long as the meter has received the necessary sign permit from the Development Services Department, permit applications are available by calling 602-262-6521.
WHAT ARE THE PENALTIES FOR POSTING SIGNS IN THE RIGHT-OF-WAY?

The fine for posting signs in the right-of-way ranges from $250 to $2,500. These fines are unassessable PER VIOLATION.

WHO WILL BE CITED FOR VIOLATIONS?

The sign ordinance allows only homeowners, residents, businesses or individuals that might reasonably believe they have placed a sign, even though they may not have actually placed the signs themselves. As always, individuals caught placing the signs in the right-of-way will be cited.

HOW CAN PRIVATE CITIZENS ADVERTISE IN THEIR NEIGHBORHOODS?

Perhaps the safest and best way to spread the word about your garage sale, holding an outdoor personal message is to advertise in one of the many newspapers and publications available around the Valley. You can also seek to advertise on neighborhood garage sale bulletin boards and on the Internet.
Cart Pick Up Brochure
These Wheels Belong in Stores – NOT NEIGHBORHOODS
From: Vincent Moreno <vincent_moreno@dot.ca.gov>
To: Hualiang.Teng@unlv.edu
cc: puli anil <chaseupuli@gmail.com>, marlene_martinez@dot.ca.gov,
paul.racs@lacity.org

Date: Fri, Aug 8, 2008 at 2:36 PM
Subject: Re: reference for the upwf

Re: thank you

Mr. Teng,

Here are some answers for your studies:

Capitol Purchase for wax-based protective coatings: low bid: $95.00 per gallon or $250.00 per 5 gallons. Operational costs for either applying, removing or maintaining any one area with graffiti: $680.00 / per minimal Shoulder closure to a high of $1070.00 for minimal lane closure. All other closures for any other area affected rises with longer approval for closure requests.
Benefits of sacrificial coating or Non Sacrificial coatings: Only benefits with fabric coatings (3M 1160 Sheeting) $3.00 sq. ft. for every metal sign plane applied. Usually only one sheet is needed with a life span of constant cleaning 3 to 5 years.

No benefit is found with soluble wax coatings neither permanent nor sacrificial in California. (NPDES) National Pollution Discharge Elimination System creates a higher cost factor to reclaim the cleansing discharge.

Fencing: Benefits exist when 6 to 9 gauge material is used for the fence fabric. Countermeasures: Current fence fabric is 11 gauge, 36 diamond 72 in wide. Installation varies for customized locations to prevent vandalism. Cost per linear foot material: $2.70 / cost to install is $6.20 per linear foot and maintenance cost rises and falls too often with an average cost of $37.20 per linear foot per year for problem areas.

Landscape Design: Counter measures planting Boston Ivy (parthenocissus tricuspidata) is the best type of vine to use in this district's climatic regions. Drought resistant, this species grows well in typical desert and minimal rain mountainous terrains.

Benefits: Nothing required except low flow water systems with sound wall surfaces at $2.30 per sq. ft. installed. All landscape projects are contracted with 3-yr plant establishment periods.

Preventative access devices: Rat guards, sign shields and or deterrent wires such as Constantine wire or barbwire. Regulations dictate usage for barb or razor wire installations. Currently, there is a moratorium of usage. Pole guards, sign shields are usually expensive and are required to be customized for airspace issues. Average price per unit varies from $1500.00 to $3500.00 for rat guard types that may not or may have a hatch for access. $500.00 for the serrated surface collar type (the cheese grader) per pole.
Sign shields all various designs and types have been tested and approved by our HQ group.

Contact: Sign Guard Co. / 619.985.2083
         Cone Door System / 1.800.345.7454

Alternatives to investigate:

Fence Fabric / Jonathan Sidy <jonathan@lateralperspectives.com>

Sincerely,

Vincent Moreno CMAS

Maint. Engr. Support
Hello Anil, I am responding to this letter for David. I had worked on the Sign crew for a number of years and helped install the Graffiti barriers on the Structural overhead signs on the DOT right of ways. I fabricated the barriers for the district and worked with the Supervisor in fighting this problem. I will answer your questions in the same format as you presented them in your letter. The responses are as follows:

1. The District has approximately 20+ barriers in place and replaces them as they are damaged from either wind or vandals from an inventory of on hand barriers. The damaged barriers are returned to our fabrication shop for repair and then repainted for re-
installation at a different location. The goal is to continue to install barriers in new locations as the need arises for a deterrent.

2. If a sign structure is hit more than 3 times in a period of one year a decision is made to place a barrier on the sign post that is used to access the State property. Sign structures are of three main types. Two post (spans the travel lanes from lane 1 to lane 3), Cantilever (one post design that projects the sign over traffic) and a butterfly (a one post design that centers the sign in the median of the highway system).

3. District I (which is Las Vegas) has approximately 30 barriers and is in the process of fabricating additional units to replace damaged in place barriers. The Northern Districts of the State have barriers also. Each District is responsible for addressing the needs of their own geographic area.

4. As a general rule, three before installation. After installation we have seen the repeat rate drop to zero for most locations, however if the sign is still being hit we modify what is deficient in the design and install the new design or change the area of access. An example of this would be changing fence fabric to corrugating sheet. The fabric allowed the vandals to bypass the barrier by giving an alternate method to access the sign structure.

5. We have only recently used anti-graffiti coatings and have not had to clean the sign that it was applied to. If the claims of the manufacturer are accurate the cost of the removal chemicals and labor will be greatly reduced. We will see in time. I hope this information helps you.

Keith Wroblewski.
BIBLIOGRAPHY


http://www.las-cruces.org/pio/graffiti/remove.shtml


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Jawaharlal Nehru Technological University, India

Thesis Title:
Evaluation of Graffiti Countermeasures on Highways

Thesis Examination Committee:
Chairperson, Dr. Hualiang (Harry) Teng, Ph. D.
Committee Member, Dr. Moses Karakouzian, Ph. D.
Committee Member, Dr. Mohammed Kaseko, Ph. D.
Graduate Faculty Representative, Dr. Ashok Singh, Ph. D.