CANYON LAKES
GEOLOGIC HAZARD ABATEMENT DISTRICT

RESERVE STUDY

July 2013

BACKGROUND

Geologic Hazard Abatement Districts were authorized by the State of California under the provisions of the 1979 Beverly Act (California Public Resources Code 26500-26601). The mission of these Districts is to provide an ongoing resource for managing geologic hazards that pose a threat to properties within the boundary of the District. The Canyon Lakes Geologic Hazard Abatement District (CLGHAD) was formed in 1985 and addresses landslide hazards within the Canyon Lakes District, which is also known as Contra Costa County Drainage Area 75A (CDA 75A). A map of the District is provided as Figure 1.

The CLGHAD is a tax exempt political entity of the State of California. Annually the CLGHAD prepares an operating budget for its July-June fiscal year, which is approved by its Board of Directors. CLGHAD's funds are held by the District Treasurer until needed for use.

The CLGHAD service territory includes approximately 3,400 living units comprising nine Home Owners Associations, and separately managed apartment complexes. The District also includes a golf course, several commercial properties, a hospital, two schools, a church, City offices, and two Water District facilities. The topography varies in elevation from about 600 feet along the western border to over 800 feet above sea level along the eastern border. The 200 feet in elevation change gives the community scenic views looking across the surrounding properties. The development was engineered so as to minimize the building of residential units near potentially unstable natural slopes. An area of the community was constructed by excavation and filling to create a level pad for the construction of the San Ramon Regional Hospital. A scenic lake feature was developed in a large depressed area near the north end of the Districts' service territory, south of Crow Canyon Road.

The mass grading work for the development was designed and constructed with features that were intended to minimize the risk of earth movement over the long term. For example, some existing historical landslides were completely removed and/or repaired, and miles of new sub drains were installed. CLGHAD monitors and maintains these improvements as part of its land slide prevention and mitigation mission.

COORDINATION WITH CLGHAD PLAN OF CONTROL

The CLGHAD Plan of Control [1] is the document which defines the District's responsibilities, exceptions and limitations. The Plan of Control gives the General Manager wide discretion in determining which projects the District undertakes in achieving its mission. Nothing in this Reserve Study is intended to modify the District's Plan of Control. Neither the inclusion of items or non-inclusion of items in this Study should be construed as a commitment or non-commitment of the District to fund specific projects.

PURPOSE OF RESERVE STUDY

The Canyon Lakes Geologic Hazard Abatement District (CLGHAD) updates the Reserve Study on regular intervals to forecast the costs that it can reasonably expect to incur in the decades ahead, and to confirm that sufficient funds are being set aside in the District's Reserve Fund to pay for these costs.

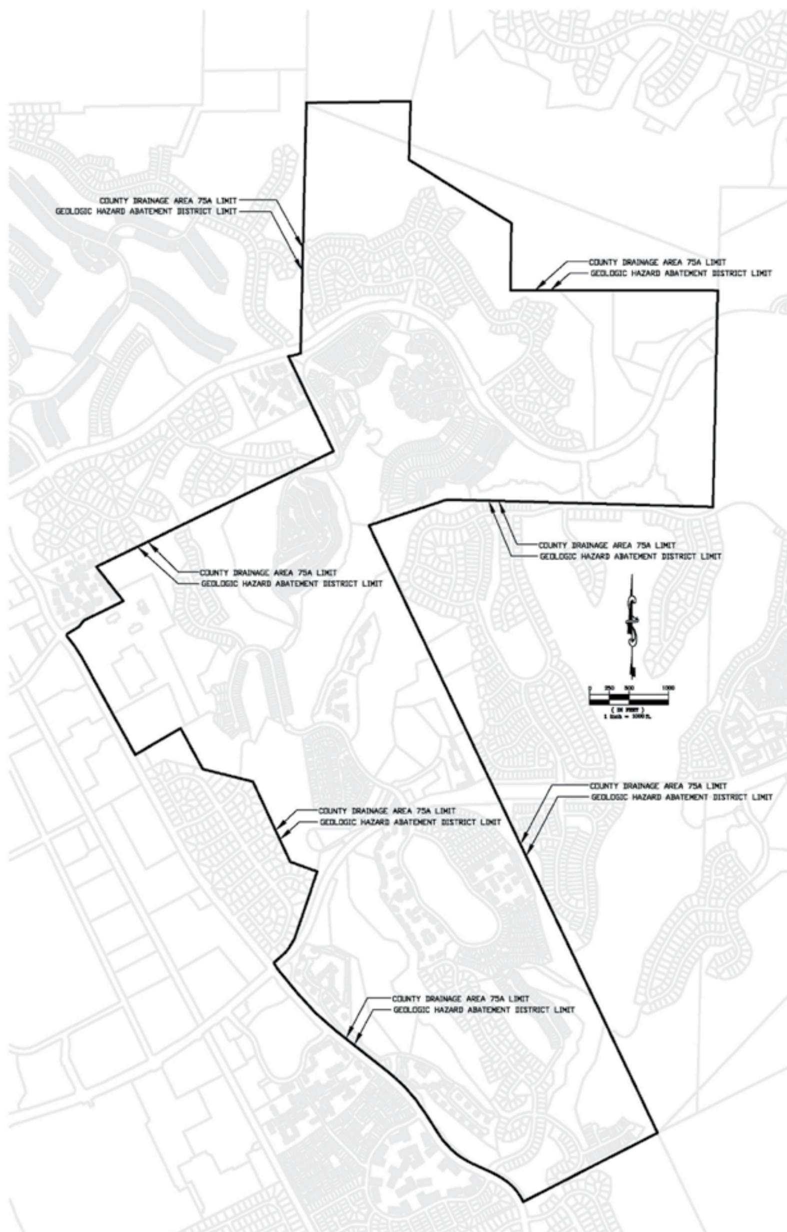


FIGURE 1 - MAP OF CLGHAD SERVICE TERRITORY

LIMITATIONS

The accuracy and reliability of this Reserve Study diminishes as the time horizon increases. The Study attempts to forecast the expenses that the District can be expected to incur over the next forty year time horizon. This horizon is used because it encompasses the infrequent impacting events that are expected to drive the need for some of the most expensive repairs that the District can expect over such a long interval. Unknown changes in both the value of money and technological improvements will impact future costs in ways not quantifiable at this time. While best efforts have been made in predicting cost impacts in the years ahead, there is real potential for variance between the Reserve Study forecasted expenses and those actually experienced. Consequently, to assure that the District's future financial needs are being met over the long term, this Reserve Study must be updated on regular intervals. These updates will properly reflect new data for costs, return intervals, service lives, and then current prevention and mitigation technologies, as they evolve.

The projected costs in this Study have been developed through a combination of science and art. The science being the hard data available for the replacement and repair costs derived from current projects of a similar nature. The art being the prediction of the severity and return intervals for significant events like major rain storms, wet (El Nino) seasons and major earthquakes, and the estimation of remaining useful life of installed infrastructure. While scientific research provides statistics which suggest reasonable estimates for some of this data, there is a real possibility that significant expense events may occur on a greater frequency than anticipated and/or at a scale in excess of that anticipated by this Reserve Study.

Actual remaining life can also vary from expected useful lives. This can occur for a number of reasons and is best determined by District specific experience, because design and construction methods do vary from location to location. Again, updating the Reserve Study on a regular basis to include actual end of life data from District specific owned assets will serve to better align projected costs and actual cost in the decades ahead.

REVENUE SOURCES

The Canyon Lakes GHAD is funded through assessments levied on property within the boundaries of the District. Assessments within the District are adjusted annually in accordance with the Consumer Price Index (CPI). An inflation adjusted property tax is assessed against property owners within the CLGHAD service territory depending on the type of housing unit (single family, townhouse, condominium/rental and commercial). The District receives this tax revenue annually, which totaled approximately $499,900 during the 2012/2013 fiscal year. Annual revenues of the CLGHAD are budgeted first to address annual operating expenses [2]. Additional revenues are reserved in accordance with projected expenses in the Reserve Cost forecast, which is the product of this Reserve Study. Reserve Funds are intended to provide the resources needed to pay for the future major maintenance and major landslide repair projects. Although infrequent, these expenses can be substantial, requiring diligence in the planning process to assure that adequate reserves are maintained. A Reserve Fund balance of $2,466,100 is projected for June 30, 2013.

In the event that the Reserve Fund balances are not sufficient to pay for all of the demands that the District might have placed upon it during a period of extraordinary expense, the California Public Resources Code allows GHAD's to issue bonds, and other debentures, to obtain commercially available loans, to receive funds from other agencies, and/or to impose assessments (subject to Proposition 218), in order to carry out its mission. Funds needed for the purpose of maintaining, monitoring, mitigating, and repairing landslides may be accessed through these means, as defined in the District's Governing Documents and as approved by its Board of Directors .

District tax revenue will continue to rise over time consistent with the rate of inflation. During the past fiscal year (2012/2013), the District put into effect a temporary reduction of contributions to its Reserve Fund. The District expects to continue at a 50% reduction in its Reserve Fund contributions through the next two fiscal years (2013-2015). 100% inflation adjusted reserve fund contributions are planned to resume in the 2015-2016 fiscal year, and continue to rise consistent with inflation rates in the ensuing years. These expected Reserve Fund contributions have been included in the Reserve Fund forecast included in this report.

ASSUMPTIONS

Inflation Rate: Taken as 3% for the next 40 years. Historical data shows that the inflation rate averaged 3.0% between 1992 and 2012, but its average was 6% between 1972 and 1992 [17]. An inflation rate in excess of 3% may be justified in future updates to this Reserve Study, depending on the prevailing economic conditions at that time.

Interest Earned: Taken as 1% for the next 40 years. Historical data shows that rates paid on high dollar interest bearing accounts (certificates of deposit) are generally 2% below the rate of inflation. A 1% return on invested funds correlates with the above assumed 3% inflation rate. If the inflation rate rises, some of the increase in costs should be offset be a higher return from interest earned on the Reserve Fund assets.

METHODOLOGY

This Reserve Study identifies and quantifies costs that can be expected by the District for the repair and/or replacement of assets it maintains and/or owns, and the repair of major landslides which fall under the District's Plan of Control. Overall costs for asset maintenance and replacement have been developed by first quantifying the assets and then multiplying those quantities by an average present day maintenance or replacement cost for each unit. Cost escalation due to inflation is accounted for by assigning an average expected inflation rate over the Reserve Study period.

The expected remaining useful life of each asset is determined by subtracting the current life of each asset from an average useful life of similar assets.

The identification and quantification of District assets have been developed through takeoffs from District infrastructure maps and with the input and review of District staff. Major maintenance and replacements costs of District assets are based on a combination of data from both direct CLGHAD project experience, and other public infrastructure maintenance and replacement projects in the San Francisco bay area.

Costs for major landslide repair have been developed based on statistical recurrence rates of known landslide initiating events, and a statistically based estimate of the cost of repair of each such recurrence.

SCOPE

This study is aligned with the District's fiscal year and forecasts capital project expenditures and needed Reserve Funds for the period of July 1, 2013 through June 30, 2052.

This Reserve Study addresses two different types of Reserve funded projects, which are expected in the years ahead. The first group is projects required for major maintenance and replacement of existing CLGHAD infrastructure assets. These assets wear out over time and require life prolonging major maintenance, or need to be replaced, in order to remain functional. The second group of projects is major land slide repair projects that need to be undertaken to mitigate soil movement. These projects may be either the result of slope instability issues that come to the attention of CLGHAD though the District's monitoring program, or they may be the result of precipitator events that include intense rainfall, unusually wet winters, earthquakes and floods.

Both of these types of Reserve funded projects are discussed below along with the basis for establishing appropriate funding.

MAJOR MAINTENANCE AND/OR REPLACEMENT OF ASSETS

Certain assets within CLGHAD's service territory are required to remain serviceable in order for CLGHAD to achieve its mission. These assets include B-58 ditches, subdrain systems, subdrain outlets and pumps, other storm drain system components, retention basins, horizontal drains, piezometers and debris benches. Some of these assets are owned by the CLGHAD, while others are outside of the District's ownership. Normal maintenance for these facilities is provided for within the District's annual operating budget. The Reserve Fund forecast includes only those expenses associated with major maintenance and replacement activities which occur on longer intervals, and are not funded as part of the annual operating budget.

B-58 DITCHES

A brief description of each of the assets requiring major maintenance and/or replacement is presented below.

B-58 DITCHES

The B-58 concrete lined drainage ditches make up a major part of the Canyon Lakes development's hillside erosion protection and storm water runoff collection system. The District maintains approximately 35,000 linear feet, or over 6.5 miles, of B-58 ditches. These ditches are owned by the underlying property owners. The proper function of these ditches is required for immediate conveyance of water (rain or otherwise) away from the slopes. Swelling and shrinkage of expansive soils underlying some of these ditches have historically resulted in the need for repairs and replacements of certain B-58 ditches whose function is deemed by the District to be critical to maintaining slope stability. Newer less expensive technologies may provide a method of extending the life of certain concrete ditches by lining them. The District intends to apply these technologies in appropriate locations, when future repair work is required.

SUBDRAINS

A network of sub-surface drains (subdrains) exists within the CLGHAD service territory. These subdrains were installed by the original developer when the original mass grading operations were underway, as the subdivisions in Canyon Lakes were being developed.

Some of these subdrain systems have their outfalls tied into the storm drain piping in underground locations, rendering them inaccessible for inspection or monitoring. The subdrain locations that do have documented outlet locations are routinely monitored by the District. CLGHAD plans to continue to monitor the outflows of the known subdrain outlet locations, which currently number 40.

SUBDRAINS

When subdrain outlet water flow yields diminish, the District responds by cleaning the subdrain system to restore functionality. In certain situations alternate remedial drainage systems, such as horizontal drains or drainage galleries, are evaluated and undertaken by the District.

The District anticipates that cleaning and augmentation of subdrain systems will be required as an ongoing maintenance item for the 40 monitored subdrain networks in its service territory

OTHER STORM WATER COLLECTION SYSTEM COMPONENTS

The District maintains 57 catch basins which are directly associated with the open space slope drainage systems. Operability of these catch basin inlets during periods of heavy rains is critical to maintaining slope drainage and stability.

In addition to the catch basins, the District maintains the directly associated storm drain piping, which conveys the storm water from the catch basin inlets and to larger neighborhood water collection arteries, which are owned or maintained by others. The ownership of the Storm Water Collection System Components resides with the underlying property owners.

RETENTION BASINS

SUBDRAIN OUTLETS/PUMPS:

The District maintains three substation subdrain pumping facility sites around the main lake at Canyon Lakes. Periodic site checks for operation are performed on regular intervals. In recent years work has been completed on the installation and implementation of an early warning system to notify GHAD staff in the event of an impending pump failure.

CLGHAD owns and maintains the three subdrain pumping facilities at the main lake.

RETENTION BASINS

The scenic lake landscape feature near the north end of the District is a storm water retention system consisting of three interconnecting lakes and a fourth lake downstream between holes 1 and 9 on the golf course. Similarly, two lakes at the southern end of the District in Coyote Canyon serve as retention basins. Both of these retention systems are designed to slow the flow of rain water during an intense storm so as to meter the outflow at a rate consistent with the downstream infrastructure. All six of these retention basin lakes have been integrated into Canyon Lakes Golf Course as water features.

The District shares the maintenance responsibilities of the six retention basin lakes with the Canyon Lakes Golf Course, the various Canyon Lakes Homeowners Associations, and the Contra Costa County Flood Control District. Major maintenance provided by the CLGHAD to the six lakes has historically been limited to landslide related repairs that would impede the water course or mobilize significant amounts of siltation.

The ownership of each of the Retention Basins/Lakes resides with the underlying property owner.

HORIZONTAL DRAINS

During the original Canyon Lakes development grading operations, horizontal drains were installed in slopes as they were being constructed to lower groundwater and enhance slope stability. The District maintains a total of 129 of these horizontal drains as a key defense against saturation of critical slopes. Approximately 18% of the population of installed horizontal drains have, over the last 27 years, been rendered non-serviceable or have become buried through the natural process of sedimentation and erosion. On a regular basis the District assesses the need for, and when determined necessary, performs a major cleaning to prolong the service life or replaces non-functioning horizontal drains.

PIEZOMETERS

The depth of ground water has a great influence on the stability of slopes. The District currently maintains 116 piezometers (ground water monitoring wells) to monitor slope conditions and slope performance with respect to changes in ground water levels. The District has experienced approximately a 25% loss of functionality of these piezometers over the last 27 years, through the natural processes of sedimentation and erosion. On a regular basis, the District assesses the need for, and when determined necessary, performs a major cleaning to prolong the service life or replaces non-functioning piezometers.

PIEZOMETERS

DEBRIS BENCHES

Throughout CLGHAD's service territory, debris benches have been constructed at the toes of the steeper slopes that are located up against private property limits. The purpose of these debris benches is to provide a buffer zone for erosion deposits to accumulate before they flow onto private property. In many of these areas debris benches also act as buttress features, providing support for the slopes above. Periodically, due to weathering and saturation, the District needs to restore these areas, or rebuild the buttress fills to restore their full functionality.

ADDITIONAL ASSETS MAY EXIST

Every effort has been made to list all of the assets that District owns and/or maintains in this Reserve Study. The District's experience is that previously unknown additional assets come to light over time, most typically sub-surface assets. Given this history, the District expects that in the years ahead additional other previously unknown assets will likely come to light. CLGHAD's plan for addressing these assets will be to incorporate them into future Reserve Study updates, as they become known. The District is committed to cataloging all of its service territory drainage assets as an ongoing effort.

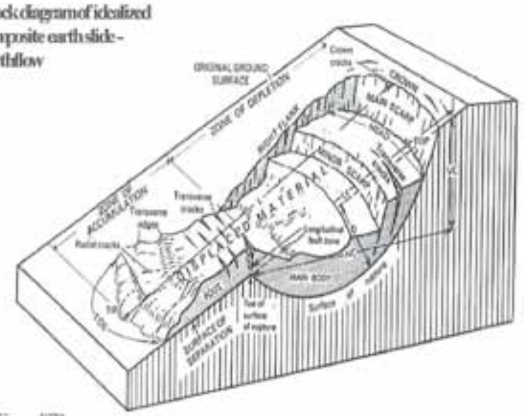
MAJOR LANDSLIDE REPAIR PROJECTS

As discussed earlier, Major Landslide Repair Projects are those that involve reinforcing and/or rebuilding slopes that have become unstable. Some of these projects are initiated to repair a slope following a long term monitoring program, while others are initiated due to unique events, such as intense rain storm, unusually wet winters, major earthquakes, and floods. A particular challenge in developing a Reserve Fund for these types of events is in establishing a reasonable forecast of their frequency of recurrence, and the extent of repairs that will be required.

A discussion of each of these unique initiating events, a basis for predicting their frequency of recurrence and the extent of required repairs is presented in detail below.

RAINFALL INITIATED HAZARDS

The incidence of land sliding is directly correlated with two different rainfall initiated hazards. These two hazards are: 1) an intense period of rain whereby a slope's natural ability to drain is overwhelmed by the intensity of the storm, and 2) wet winter (El Nino) seasonal rainfall whereby slopes become super saturated for an extended period of time. In both cases the lubricating effect of the water along the surface of rupture, in combination with the higher weight of the wetted soil synergize to cause a mass of earth material to break free from the underlying base earth material, resulting in a landslide.



Block diagram of idealized composite earth slide - earthflow

From Varnes 1978

Empirical data indicates that the number of landslides near the San Ramon area of Contra Costa County were shown to have increased dramatically after the intensity of the rainfall rose above 3.5 inches per day [3]. Based on this information, the criterion used in this Reserve Study for intense rainfall initiated hazards is rainfall in excess of 3.5 inches in a day.

To develop a reasonable return period for unusually wet winters (El Nino), an evaluation of rainfall records was performed. Historical records near San Ramon indicate that in winter seasons where the total rainfall exceeds 1.5 times the average rainfall, the number and damaging effect of landslides increases [4]. Based on this information, the criterion used in this Reserve Study as a trigger for unusually wet winter (El Nino) initiated hazards is rainfall in excess of 1.5 times the mean seasonal precipitation (MSP).

The MSP for the Canyon Lakes area between 1879 and 1973 is 21.0 inches [5]. Extrapolating the recurrence Interval data published by the Contra Costa County suggests that rainfall exceeding 3.5 inches in a day can be expected to recur on a 5.5 year interval, and that rainfall in excess of 1.5 times the MSP can be expected to recur on a 15 year interval [5, 7].

Research conducted by the United States Geological Society aimed at predicting changes in precipitation in the San Francisco bay region over the next several decades, reached the general conclusion that despite an expected rise in mean ambient temperature by 2 to 3 degrees Celsius over the next 40 years due to global warming, precipitation in the region will remain the same or decrease [6]. This suggests that the rain intervals do not need to be adjusted to account for the predicted effects of global warming.

MAJOR EARTHQUAKE INITIATED HAZARDS

There is widespread agreement in the published research correlating major earthquake ground motion to landslides. Further, there is evidence that earthquake induced land sliding typically occurs at the same location as historical slides [8, 9]. The CLGHAD service territory includes 30 historical landslides that were identified as active during the Canyon Lakes development grading operations. It is these slides that pose the greatest risk of becoming unstable in the event of a major earthquake [18]. The CLGHAD territory is exposed to earthquake risk from both local fault lines (Marsh Creek, Concord, Calaveras, Las Positas) and from major fault lines capable of very large earthquakes (Hayward and San Andreas). Horizontal accelerations caused by earthquakes generally dissipate the further the distance from the earthquake epicenter [8, 10]. Therefore, horizontal accelerations from major earthquakes on the San Andreas and Hayward fault lines can be expected to have dissipated somewhat by the time that they reach the CLGHAD service territory. Smaller, but significant earthquakes on the local faults (Calaveras, Concord, Marsh Creek, and Las Positas) probably pose a higher risk of inducing landslides within the CLGHAD service territory due to their closer proximity. Scientists have not yet determined an accurate way of predicting earthquake locations and magnitudes. However, probabilistic approaches to establish earthquake risk have been used as reasonable planning tools in the absence of an ability to predict earthquakes.

The last time that the San Francisco bay area experienced a significant earthquake with horizontal forces of sufficient magnitude to be of interest in triggering landslides, was the Loma Preita earthquake, which occurred on October 17, 1989. Even though this was a major earthquake, because the intensity of the shaking diminishes with distance, USGS generated Shakemap intensities for this earthquake indicate that the maximum horizontal ground motion was less than 0.18g in the CLGHAD service territory [12]. A swarm of earthquakes of smaller magnitude more local to the CLGHAD service territory occurred in San Ramon in 2002. The largest earthquake in this swarm generated a peak acceleration of approximately 0.04g in the CLGHAD service territory [13, 14, 15]. No landslide activity was observed in the CLGHAD Territory, which can be associated with either of these two earthquake sequences.

Lacking direct CLGHAD experience correlating ground motion in the San Ramon area to CLGHAD service territory landslides, it is necessary to use other less direct methods to establish an expected return rate of seismic events of sufficient magnitude to cause land sliding. Based on empirical information available at this time, earthquakes which produce a local lateral acceleration force in excess of 0.15g are believed to be of sufficient size to initiate some land sliding [16]. The recurrence interval for earthquakes capable of causing a ground motions in excess of .15g has been studied and results have been compiled in a report prepared by the USGS [9]. The USGS's research suggests a 77.4% chance of such an earthquake occurring in the San Francisco Bay area over the next 30 years. This includes all earthquakes causing a 0.15g horizontal acceleration at any given location in the San Francisco bay region. The frequency of a 0.15g horizontal acceleration in CLGHAD's service territory can be expected to be less, as not every earthquake of this magnitude in the San Francisco bay region will deliver a 0.15g horizontal acceleration in CLGHAD's service territory. How much less is an educated guess. This Reserve Study update applies a 50% reduction to the San Francisco bay region probability. Meaning that the return period for a 0.15g horizontal force earthquake in the CLGHAD service territory is twice the return period for a similar quake anywhere in the bay area region. Accordingly, this Reserve Study converts the statistical probability 77.4% in 30 years for the Bay region to an event return rate of (30/0.774) x 2 = 1 major earthquake initiating landslide event in the CLGHAD service territory every 78 years. As the science of predicting earthquakes improves over time, the return rate can be adjusted in future Reserve Study updates to reflect the most current information.

FLOOD INITIATED HAZARDS

In addition to slope stability challenges that are predicted to occur directly from rain fall on the slopes within the CLGHAD service territory, consideration needs to be given to the secondary effects of water accumulation in low lying areas that can be expected to occur if the storm drain system becomes overwhelmed. Specific concern is for situations where the toe of a slope might be completely under flood waters at the same time as the top of the slope is being inundated by rain. Such situations could be expected to increase the likelihood and severity of land sliding.

The California Department of Water Resources has published Federal Emergency Management Flood Maps, which identify the areas expected to be underwater following a flood with a statistical return rate of once every 100 years (100 year flood). An analysis of those areas that are predicted by FEMA to be underwater following a 100 year flood indicates that the areas within the CLGHAD service territory involved do not overlap with the mapped toes of previously identified active slides [19]. Accordingly, this Reserve Study does not include additional reserves for Flood Initiated Hazards.

SEVERE EVENT EMERGENCY RESPONSE

Corresponding with severe rain events, or following large scale seismic events, the CLGHAD is prepared to respond with measures to assess the damage to slopes within its service territory, and to provide immediate mitigation aimed at preventing the escalation of the evolving emergency situation. These activities are associated with severe events and are in excess the Emergency Response provided annually under the CLGHAD's Preventive Maintenance program.

Severe Event Emergency Response activities of the CLGHAD include:

- Simultaneous and prolonged assessment and monitoring of multiple slopes
- Sustained mutual aid response in cooperation with other jurisdictional agencies (CERT – Community Emergency Response Team)
- Soil movement prevention and mitigation triage on multiple slopes over a sustained period of intense rain or following a major seismic event.
- Life line Infrastructure and/or access restoration to insure public health and safety. In a severe incident where common infrastructure has become compromised, CLGHAD staff, consultants, and contractors would require access to the various impacted sites.
- Engineering support and other specific services needed to address emergent hazards.

COSTS OF REPAIRING LANDSLIDES

It is difficult to predict the extent of land sliding that will occur following a landslide initiating event (i.e.: heavy rain, wet winter, earthquake, and flood). And, consequently it is a special challenge to estimate the amount of repair cost that might be incurred by the CLGHAD following such an event. Nevertheless, we rely on statistical data from research to provide some basis from which to forecast the magnitude of future land slide repair costs.

Historical landslide mapping information for the CLGHAD service territory was studied as part of the Reserve Study update. The 30 mapped landslides that were identified as being "active" at the time that Canyon Lakes development was graded have been grouped into three different repair cost categories [18]. Due to the extensive mass grading done as part of the Canyon Lakes development, slides not identified as active are believed to be a stabilized for the most part at this time. The three cost categories and their criteria being:

1. Low cost – active slides areas with slopes of less than 5:1; slide areas of less than ¼ acre areas; up to 3:1 slopes where previous slope stabilization work has been completed using engineered fills, benches, and/or enhanced drainage; historical slide areas of any slope where no infrastructure or site improvements exist above or below the mapped slide area.
2. Average cost – active slide areas with slopes between 5:1 and 3:1 where no slope stabilization work has been done, and with only a modest amount of infrastructure below or above the mapped slide area.
3. High cost – active slide areas with slopes between 5:1 and 3:1 where no slope stabilization work has been done, and a significant amount of infrastructure and/or buildings/improvements exist below or above the mapped slide area.

Beginning in 1975, the US Geological Society compiled data and has done much research aimed at helping public agencies plan for future direct costs associated with the repair of future landslides in the San Francisco Bay area. In 2008, the USGS published a report entitled: Significant Landslide Risk in the San Francisco Bay Region [16]. The report presents historical data on past mean direct costs of a typical landslide in each of the nine bay area counties. This data has been extracted from repair costs for more than 2500 landslide repairs over a 35 year period. The historical data provided in this report is presented in the base year of 2000 dollars. This data can be escalated by applying a cost inflation factor to arrive at equivalent 2013 costs. By definition, some of the landslides will be more expensive to repair than the mean and some will be less expensive. Budgeting for these costs based on a mean cost includes the inherent risk that the initial slides requiring repair may be more expensive than the mean projected cost. Over a long period of time, it is reasonable to expect that the actual cost of landslide repairs will align with forecasted mean costs.

Direct repair costs are those costs associated with repair of the slope. These costs do not include indirect costs which are the costs associated with repair of infrastructure and other site improvements which may also be damaged by a landslide. CLGHAD's Plan of Control document limits the District's responsibility for indirect costs, other than its own assets, which are estimated to be no more than 10% of the direct costs.

The USGS report found that for Contra Costa County the mean cost of repair for a landslide was $216,000 in year 2000 dollars [16]. The inflation rate from the year 2000 to 2013 is 1.36 [17]. Applying an additional 10% for repair of CLGHAD owned/maintained infrastructure, the mean landslide repair cost for the average cost landslide repair can be calculated a:s $216,000 x 1.36 x 1.1 = $323,000 in 2013 dollars. Low cost landslide repairs are taken as one-third this amount, or $108,000. High cost landslide repairs are taken as 3 times the average amount or $970,000.

COST PER INITIATING EVENT

As discussed above, there are three types of initiating events to be accounted for in the future cost forecasting:

1. Intense Rainfall event exceeding 3.5 inches of rain in a day with a 5.5 year return interval
2. Wet Season (el Niño) event exceeding 1.5 times the mean annual precipitation with a 15 year return interval
3. Seismic Event exceeding 0.15g horizontal acceleration with a 78 year return interval

In order to establish the total repair costs of each of these events, an estimation of how many and what size of landslide will require repair following each of these initiating events has to be made.

Two (2) intense rainfall events have occurred in recent years with nearby recordings of 3.76 inches of rain on 11/30/12, and 4.70 inches on 10/13/09 [7]. During this same time frame, the District has embarked on 2 major slide repair projects [20]. Based on this historical data, this Reserve Study update is based on repairing one average cost landslide per intense rainfall event – exceeding 3.5 inches of rain in a 24 hour period.

The most recent years that annual rainfall exceeded 1.5 times the MSP near San Ramon were the years 1998, 1996, and 1995. There were 10 landslides reported in the District territory which correlate to these Wet Season (El Nino) years [20]. Based on this District history, this Reserve Study update is based on repairing 3.33 average cost landslides per rainfall in excess of 1.5 times the MSP event.

There were no reported landslides in the District service territory that occurred as a result of recent earthquakes. Given the ground motion from the 1989 Loma Prieta quake being only slightly higher than the expected threshold necessary to initiate land sliding, little can be concluded from the fact that no new slides were observed in the CLGHAD service territory from this earthquake. The District maintains a data base of historic slides mapped in its service territory. This list indicates that there are 30 slides that were identified as active at the time that the Canyon Lakes area was developed. Considering the well documented expectation that historical landslides are reactivated in general proportion to earthquake ground motion, it is reasonable to plan on multiple reactivated historical landslides resulting from a major seismic event. At the same time it would not be expected that all recently active landslides would be reactivated – especially considering that it is known that some landslides don't reactivate for hundreds of years, which would infer that major seismic events recur at a greater frequency than the reactivation of individual landslides. Lacking a more sophisticated basis to rely on, it seems reasonable to assume that roughly 20% of these active landslides will need repairs following an earthquake that generates a greater than 0.15g horizontal ground motion inside of the CLGHAD service territory. Based on the relative number of each that exists in the CLGHAD service territory, six (6) landslides will be assumed to require repair following a major seismic event. This will include three (3) high cost landslide repairs, and three (3) low cost landslide repairs. Based on the previously developed cost of each, these repairs would be projected to total approximately $3,230,000 in 2013 dollars.

CONCLUSIONS AND RECOMMENDATIONS

The Reserve Fund cost forecast for the next 40 years are shown in the Attachment A tables and figures. The Reserve Fund balances indicate that the projected level of annual Reserve Fund contribution is sufficient to fund the District's projected major maintenance and landslide repair expenses, provided that sufficient annual contributions continue to be made as scheduled, and that the expenses for a multiple major landslide repair scenario don't occur early in the projected time horizon.

The methodology used in this Reserve Study provides a blueprint for regularly assessing the adequacy of the District's Reserve Fund. Because the predictability of landslide initiating events is based on many unproven theories and assumptions, this Reserve Study should be updated on intervals not exceeding five years to incorporate evolving predictive methods, actual CLGHAD expenditures and account balances.

Lastly, it is noted that the dollar amounts available in CLGHAD's Reserve Fund in the current fiscal year may not exactly match the amount shown in the forecast and analysis. This difference does not materially affect the year-to-year projections of the study and will be reconciled in the next Reserve Study update analysis.

REFERENCES

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11. 2009 Countywide Comprehensive Transportation Plan Final Environmental Impact report, SCH#2008052073, Adopted June 17, 2009 by the Contra Costa Transportation Authority.

12. US Geologic Survey Earthquake Hazards Program Shake Map for Loma Prieta Earthquake, Tuesday, Oct 17, 1989, 5:04 PM PDT

13. US Geologic Survey Earthquake Hazards Program Shake Map for nc40138528 Earthquake, November 24, 2002, 6:54 AM

14. US Geologic Survey Earthquake Hazards Program Shake Map for nc40138660 Earthquake, November 24, 2002, 4:38 AM

15. Map of Background Seismicity, San Ramon Swarm, California Integrated Seismic Network; http://www.cisn.org/special/evt.02.11.24/map.html

16. US Geologic Survey – Significant Landslide Risk in the San Francisco Bay Region, by J.A. Coe and R.A. Crovelli, June 2008

17. CPI Inflation Calculator: http://data.bls.gov

18. Compilation of Historic Landslide Data, in the Canyon Lakes Geological Hazard District's Service Territory, published by ATI Architects and Engineers, dated May 17, 2013

19. 100 Year Flood Map for Canyon Lakes, California, published by California Department of Water Resources, http://gis.bam.water.ca.gov

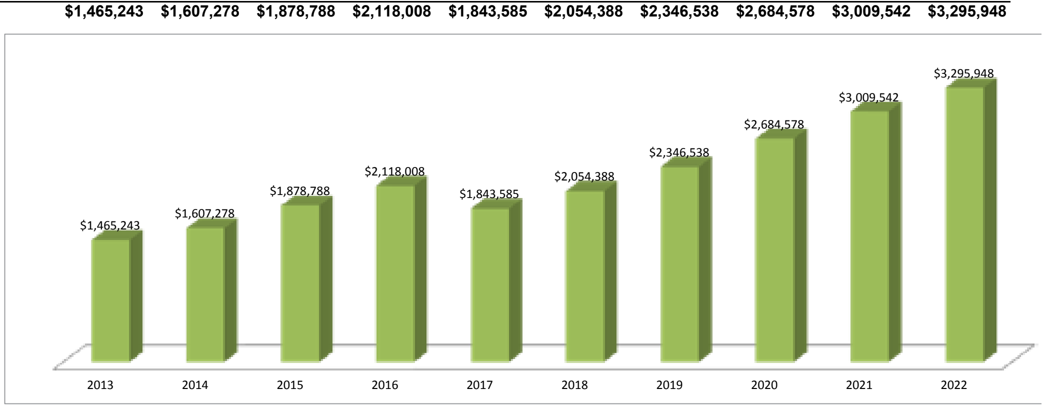
20. CLGHAD Incident Review Report from District database.

■ PROJECTED EXPENDITURES (2013-2022)

RESERVE COMPONENTS	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	Fiscal Year July 1 ... June 30...	(1) 2013 2014	(2) 2014 2015	(3) 2015 2016	(4) 2016 2017	(5) 2017 2018	(6) 2018 2019	(7) 2019 2020	(8) 2020 2021	(9) 2021 2022	(10) 2022 2023
Inflation Rate				0.03	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30	1.34
B-58 DITCHES														
1 - Replacement														
5 yr remaining life	$148,680	30	5						$172,361					
20 yr remaining life	$297,360	45	20											
35 yr remaining life	$1,759,228	60	35 **											
SUBDRAINS:														
2 - Major maintenance														
5 yr remaining life	$72,000	70	5							$85,972				
15 yr remaining life	$145,000	70	15											
25 yr remaining life	$145,000	70	25											
35 yr remaining life	$145,000	70	35 **											
STORM DRAIN PIPING/SYSTEMS:														
3 - Replacement **														
50 yr remaining life	$110,000	75	50 *											
53 yr remaining life	$230,000	75	53 *											
55 yr remaining life	$150,000	75	55 *											
RETENTION BASINS:														
4 - Major Maintenance	$30,000	3	1		$30,900			$32,782			$35,822			$39,143
HORIZONTAL DRAINS:														
5 - Major Cleaning														
5 yr remaining life	$5,160	50	5						$6,161					
15 yr remaining life	$10,320	50	15											
25 yr remaining life	$10,320	50	25											
35 yr remaining life	$10,320	50	35											
PIEZOMETERS:														
6 - Replacement														
5 yr remaining life	$25,778	50	5						$30,780					
15 yr remaining life	$51,556	50	15											
25 yr remaining life	$51,556	50	25											
35 yr remaining life	$51,556	50	35											
DEBRIS BENCHES:														
7 - Major Maintenance	$18,000	3	3				$19,669			$21,493			$23,486	
SEVERE EVENT RESPONSE														
8 - Response	$25,000	6	3					$28,138						$33,598
EXCESSIVE RAINFALL HAZARD:														
9 - 3.5" in 24 hour period	$323,000	5.5	5						$374,446					
10 - 1.5 x mean season precipitation	$1,076,600	15	1		$1,108,898									
MAJOR EARTHQUAKE HAZARD														
11 - > .15g horizontal force *	$3,230,000	78	44											
TOTAL EXPENDITURES	**$8,121,432**				**$1,139,798**	**$0**	**$19,669**	**$60,920**	**$583,748**	**$107,465**	**$35,822**	**$0**	**$23,486**	**$72,741**

* Costs for items with recurrence intervals greater than 40 years into the future, are modeled with 1/2 the cost at 1/2 the interval, in order to include the cost in the cost model..
** the expense of a major replacement program is spread out over a few years to reflect a phased implementation as would be required in actuality.

PROJECTED CASH BALANCE	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	(1) 2013 2014	(2) 2014 2015	(3) 2015 2016	(4) 2016 2017	(5) 2017 2018	(6) 2018 2019	(7) 2019 2020	(8) 2020 2021	(9) 2021 2022	(10) 2022 2023
RESERVE CONTRIBUTION				$136,475	$140,569	$289,573	$298,260	$307,208	$316,424	$325,917	$335,694	$345,765	$356,138
Average Per Living Unit Per Month (3400 living units)				$3.34	$3.45	$7.10	$7.31	$7.53	$7.76	$7.99	$8.23	$8.47	$8.73
Percentage Increase to Reserves					3.0%	106.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SPECIAL ASSESSMENTS				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
INTEREST EARNED (@1.0%)				$2,466	$1,465	$1,607	$1,879	$2,118	$1,844	$2,054	$2,347	$2,685	$3,010
ENDING BALANCE				**$1,465,243**	**$1,607,278**	**$1,878,788**	**$2,118,008**	**$1,843,585**	**$2,054,388**	**$2,346,538**	**$2,684,578**	**$3,009,542**	**$3,295,948**

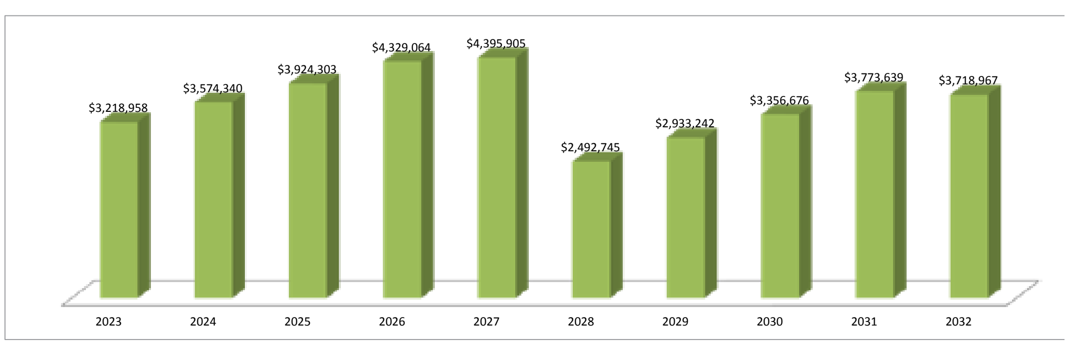


PROJECTED EXPENDITURES (2023-2032)

RESERVE COMPONENTS	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	Fiscal Year July 1 ... June 30...	(11) 2023 2024	(12) 2024 2025	(13) 2025 2026	(14) 2026 2027	(15) 2027 2028	(16) 2028 2029	(17) 2029 2030	(18) 2030 2031	(19) 2031 2032	(20) 2032 2033
Inflation Rate				0.03	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75	1.81
B-58 DITCHES														
1 - Replacement														
5 yr remaining life	$148,680	30	5											
20 yr remaining life	$297,360	45	20											$537,065
35 yr remaining life	$1,759,228	60	35 **											
SUBDRAINS:														
2 - Major maintenance														
5 yr remaining life	$72,000	70	5											
15 yr remaining life	$145,000	70	15						$225,905					
25 yr remaining life	$145,000	70	25											
35 yr remaining life	$145,000	70	35 **											
STORM DRAIN PIPING/SYSTEMS:														
3 - Replacement **														
50 yr remaining life	$110,000	75	50 *											
53 yr remaining life	$230,000	75	53 *											
55 yr remaining life	$150,000	75	55 *											
RETENTION BASINS:														
4 - Major Maintenance	$30,000	3	1				$42,773			$46,739			$51,073	
HORIZONTAL DRAINS:														
5 - Major Cleaning														
5 yr remaining life	$5,160	50	5											
15 yr remaining life	$10,320	50	15						$16,078					
25 yr remaining life	$10,320	50	25											
35 yr remaining life	$10,320	50	35											
PIEZOMETERS:														
6 - Replacement														
5 yr remaining life	$25,778	50	5											
15 yr remaining life	$51,556	50	15						$80,322					
25 yr remaining life	$51,556	50	25											
35 yr remaining life	$51,556	50	35											
DEBRIS BENCHES:														
7 - Major Maintenance	$18,000	3	3			$25,664			$28,043			$30,644		
SEVERE EVENT RESPONSE														
8 - Response	$25,000	6	3							$40,118				
EXCESSIVE RAINFALL HAZARD:														
9 - 3.5" in 24 hour period	$323,000	5.5	5		$447,108					$518,320				
10 - 1.5 x mean season precipitation	$1,076,600	15	1							$1,727,627				
MAJOR EARTHQUAKE HAZARD														
11 - > .15g horizontal force *	$3,230,000	78	44											
TOTAL EXPENDITURES	**$8,121,432**				**$447,108**	**$25,664**	**$42,773**	**$0**	**$350,349**	**$2,332,804**	**$0**	**$30,644**	**$51,073**	**$537,065**

* Costs for items with recurrence intervals greater than 40 years into the future, are modeled with 1/2 the cost at 1/2 the interval, in order to include the cost in the cost model..
** the expense of a major replacement program is spread out over a few years to reflect a phased implementation as would be required in actuality.

PROJECTED CASH BALANCE	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	(11) 2023 2024	(12) 2024 2025	(13) 2025 2026	(14) 2026 2027	(15) 2027 2028	(16) 2028 2029	(17) 2029 2030	(18) 2030 2031	(19) 2031 2032	(20) 2032 2033
TOTAL EXPENDITURES	**$8,121,432**			**$447,108**	**$25,664**	**$42,773**	**$0**	**$350,349**	**$2,332,804**	**$0**	**$30,644**	**$51,073**	**$537,065**
RESERVE CONTRIBUTION				$366,822	$377,827	$389,161	$400,836	$412,861	$425,247	$438,005	$451,145	$464,679	$478,619
Average Per Living Unit Per Month (3400 living units)				$8.99	$9.26	$9.54	$9.82	$10.12	$10.42	$10.74	$11.06	$11.39	$11.73
Percentage Increase to Reserves				3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SPECIAL ASSESSMENTS				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
INTEREST EARNED (@1.0%)				$3,296	$3,219	$3,574	$3,924	$4,329	$4,396	$2,493	$2,933	$3,357	$3,774
ENDING BALANCE				**$3,218,958**	**$3,574,340**	**$3,924,303**	**$4,329,064**	**$4,395,905**	**$2,492,745**	**$2,933,242**	**$3,356,676**	**$3,773,639**	**$3,718,967**

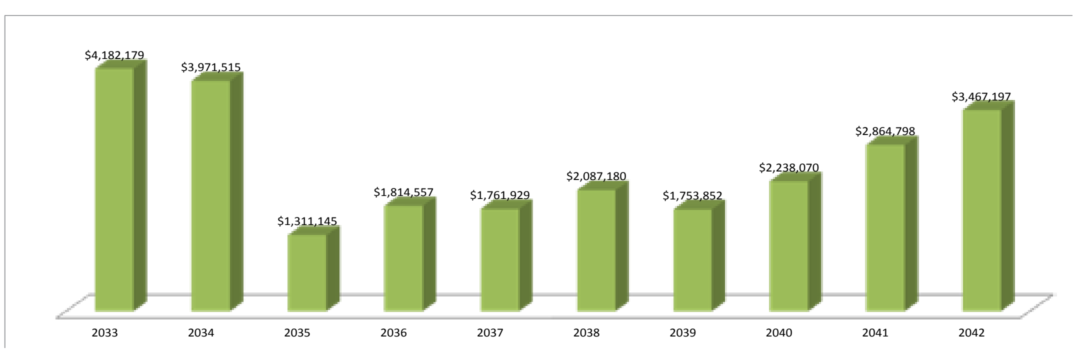


PROJECTED EXPENDITURES (2033-2042)

RESERVE COMPONENTS	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	Fiscal Year July 1 ... June 30...	(21) 2033 2034	(22) 2034 2035	(23) 2035 2036	(24) 2036 2037	(25) 2037 2038	(26) 2038 2039	(27) 2039 2040	(28) 2040 2041	(29) 2041 2042	(30) 2042 2043
Inflation Rate				0.03	1.86	1.92	1.97	2.03	2.09	2.16	2.22	2.29	2.36	2.43
B-58 DITCHES														
1 - Replacement														
5 yr remaining life	$148,680	30	5											
20 yr remaining life	$297,360	45	20											
35 yr remaining life	$1,759,228	60	35 **											
SUBDRAINS:														
2 - Major maintenance														
5 yr remaining life	$72,000	70	5											
15 yr remaining life	$145,000	70	15											
25 yr remaining life	$145,000	70	25						$303,598					
35 yr remaining life	$145,000	70	35 **											
STORM DRAIN PIPING/SYSTEMS:														
3 - Replacement **														
50 yr remaining life	$110,000	75	50 *						$115,158					
53 yr remaining life	$230,000	75	53 *							$248,008				
55 yr remaining life	$150,000	75	55 *								$166,597			
RETENTION BASINS:														
4 - Major Maintenance	$30,000	3	1			$55,809			$60,984			$66,639		
HORIZONTAL DRAINS:														
5 - Major Cleaning														
5 yr remaining life	$5,160	50	5											
15 yr remaining life	$10,320	50	15											
25 yr remaining life	$10,320	50	25						$21,608					
35 yr remaining life	$10,320	50	35											
PIEZOMETERS:														
6 - Replacement														
5 yr remaining life	$25,778	50	5											
15 yr remaining life	$51,556	50	15											
25 yr remaining life	$51,556	50	25						$107,946					
35 yr remaining life	$51,556	50	35											
DEBRIS BENCHES:														
7 - Major Maintenance	$18,000	3	3		$33,485			$36,590			$39,983			$43,691
SEVERE EVENT RESPONSE														
8 - Response	$25,000	6	3			$47,903						$57,198		
EXCESSIVE RAINFALL HAZARD:														
9 - 3.5" in 24 hour period	$323,000	5.5	5			$618,901					$717,476			
10 - 1.5 x mean season precipitation	$1,076,600	15	1											
MAJOR EARTHQUAKE HAZARD														
11 - > .15g horizontal force *	$3,230,000	78	44				$3,187,342							
TOTAL EXPENDITURES	**$8,121,432**				**$33,485**	**$722,613**	**$3,187,342**	**$36,590**	**$609,293**	**$248,008**	**$924,056**	**$123,837**	**$0**	**$43,691**

* Costs for items with recurrence intervals greater than 40 years into the future, are modeled with 1/2 the cost at 1/2 the interval, in order to include the cost in the cost model..
** the expense of a major replacement program is spread out over a few years to reflect a phased implementation as would be required in actuality.

PROJECTED CASH BALANCE	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	(21) 2033 2034	(22) 2034 2035	(23) 2035 2036	(24) 2036 2037	(25) 2037 2038	(26) 2038 2039	(27) 2039 2040	(28) 2040 2041	(29) 2041 2042	(30) 2042 2043
RESERVE CONTRIBUTION				$492,978	$507,767	$523,000	$538,690	$554,851	$571,497	$588,642	$606,301	$624,490	$643,225
Average Per Living Unit Per Month (3400 living units)				$12.08	$12.45	$12.82	$13.20	$13.60	$14.01	$14.43	$14.86	$15.31	$15.77
Percentage Increase to Reserves				3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SPECIAL ASSESSMENTS				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
INTEREST EARNED (@1.0%)				$3,719	$4,182	$3,972	$1,311	$1,815	$1,762	$2,087	$1,754	$2,238	$2,865
ENDING BALANCE				**$4,182,179**	**$3,971,515**	**$1,311,145**	**$1,814,557**	**$1,761,929**	**$2,087,180**	**$1,753,852**	**$2,238,070**	**$2,864,798**	**$3,467,197**

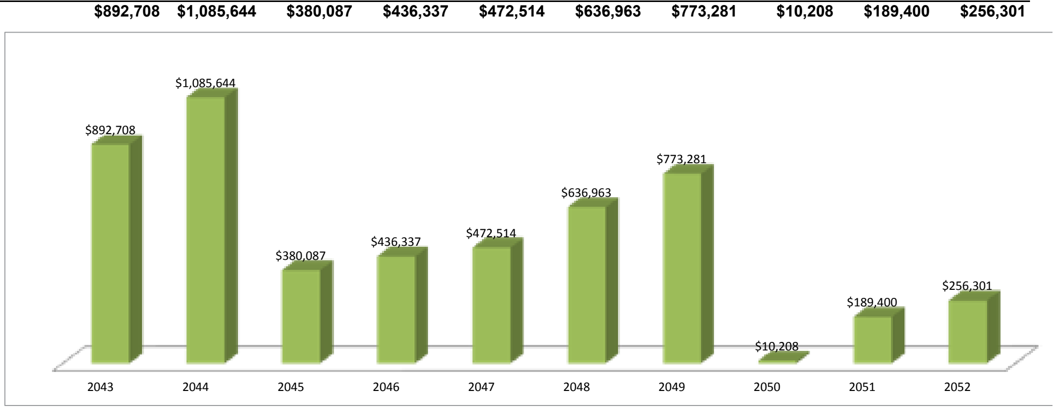


PROJECTED EXPENDITURES (2043-2052)

RESERVE COMPONENTS	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	Fiscal Year July 1 … June 30…	(30) 2042 2043	(31) 2043 2044	(32) 2044 2045	(33) 2045 2046	(34) 2046 2047	(35) 2047 2048	(36) 2048 2049	(37) 2049 2050	(38) 2050 2051	(39) 2051 2052	(40) 2052 2053
Inflation Rate				0.03	2.43	2.50	2.58	2.65	2.73	2.81	2.90	2.99	3.07	3.17	3.26
B-58 DITCHES															
1 - Replacement															
5 yr remaining life	$148,680	30	5												
20 yr remaining life	$297,360	45	20												
35 yr remaining life	$1,759,228	60	35 **			$439,821	$453,016	$466,606	$480,604	$495,023	$509,873	$525,169	$540,925	$557,152	$573,867
SUBDRAINS:															
2 - Major maintenance															
5 yr remaining life	$72,000	70	5												
15 yr remaining life	$145,000	70	15												
25 yr remaining life	$145,000	70	25												
35 yr remaining life	$145,000	70	35 **			$36,251	$37,339	$38,459	$39,613	$40,801	$42,025	$43,286	$44,584	$45,922	$47,300
STORM DRAIN PIPING/SYSTEMS:															
3 - Replacement **															
50 yr remaining life	$110,000	75	50 *												
53 yr remaining life	$230,000	75	53 *												
55 yr remaining life	$150,000	75	55 *												
RETENTION BASINS:															
4 - Major Maintenance	$30,000	3	1			$72,818			$79,570			$86,948			$95,011
HORIZONTAL DRAINS:															
5 - Major Cleaning															
5 yr remaining life	$5,160	50	5												
15 yr remaining life	$10,320	50	15												
25 yr remaining life	$10,320	50	25												
35 yr remaining life	$10,320	50	35							$29,039					
PIEZOMETERS:															
6 - Replacement															
5 yr remaining life	$25,778	50	5												
15 yr remaining life	$51,556	50	15												
25 yr remaining life	$51,556	50	25												
35 yr remaining life	$51,556	50	35							$145,070					
DEBRIS BENCHES:															
7 - Major Maintenance	$18,000	3	3		$43,691			$47,742			$52,169			$57,006	
SEVERE EVENT RESPONSE															
8 - Response	$25,000	6	3						$68,298						$81,551
EXCESSIVE RAINFALL HAZARD:															
9 - 3.5" in 24 hour period	$323,000	5.5	5					$856,704					$993,155		
10 - 1.5 x mean season precipitation	$1,076,600	15	1			$2,691,586									
MAJOR EARTHQUAKE HAZARD															
11 - > .15g horizontal force *	$3,230,000	78	44												
TOTAL EXPENDITURES	**$8,121,432**				**$43,691**	**$3,240,477**	**$490,354**	**$1,409,511**	**$668,085**	**$709,933**	**$604,067**	**$655,404**	**$1,578,664**	**$660,081**	**$797,728**

* Costs for items with recurrence intervals greater than 40 years into the future, are modeled with 1/2 the cost at 1/2 the interval, in order to include the cost in the cost model..
** the expense of a major replacement program is spread out over a few years to reflect a phased implementation as would be required in actuality.

PROJECTED CASH BALANCE	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	(31) 2043 2044	(32) 2044 2045	(33) 2045 2046	(34) 2046 2047	(35) 2047 2048	(36) 2048 2049	(37) 2049 2050	(38) 2050 2051	(39) 2051 2052	(40) 2052 2053
RESERVE CONTRIBUTION				$662,521	$682,397	$702,869	$723,955	$745,674	$768,044	$791,085	$814,818	$839,262	$864,440
Average Per Living Unit Per Month (3400 living units)				$16.24	$16.73	$17.23	$17.74	$18.28	$18.82	$19.39	$19.97	$20.57	$21.19
Percentage Increase to Reserves				3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
SPECIAL ASSESSMENTS				$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
INTEREST EARNED (@1.0%)				$3,467	$893	$1,086	$380	$436	$473	$637	$773	$10	$189
ENDING BALANCE				**$892,708**	**$1,085,644**	**$380,087**	**$436,337**	**$472,514**	**$636,963**	**$773,281**	**$10,208**	**$189,400**	**$256,301**



MISSION STATEMENT

Prevent, mitigate, abate or control geologic hazards within the District, through:

Strict adherence to the District's governing documents and plan of control

Maintaining reliable and useful access to constituents

Operating using sound and responsible financial management

Canyon Lakes Geologic Hazard Abatement District

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Phone: 925.964.0823