BLACKHAWK

GEOLOGIC HAZARD ABATEMENT DISTRICT

RESERVE STUDY

March 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 Blackhawk Geologic Hazard Abatement District (BGHAD) was formed in 1986 and addresses landslide hazards within the Blackhawk District known as Contra Costa County Service Area M-23 (CSA M-23).

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

A geological legacy of steep topography, fractured bedrock and expansive soils combine to result in an elevated potential for landslides within the BGHAD service territory. These hillside areas are also prone to soil erosion which can further add to slope instability risk.

As part of the development of the Blackhawk neighborhoods, much effort and resources were invested in establishing slopes that would remain stable over the long term. For instance, slopes were graded no steeper than(3) horizantal to (1) vertical, engineered fill benches were installed at the base of certain slopes, some existing historical landslides were completely removed and/or repaired, and miles of drainage systems were installed. BGHAD monitors and maintains these improvements as part of its land slide prevention and mitigation mission.

COORDINATION WITH BGHAD PLAN OF CONTROL

The BGHAD Plan of Control [2] 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 Blackhawk Geologic Hazard Abatement District (BGHAD) performs a 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.

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 unquantifiable 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 firm grounding of replacement and repair costs in hard numbers 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 suggests statistics which can be reasonably relied upon in estimating the District's financial reserve need, the 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, exists.

Actual remaining life can 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 of District specific owned assets will serve to align projected costs and reality in the decades ahead.

REVENUE SOURCES

CSA M-23 serves as the primary funding mechanism for the District. An ad valorem property tax is assessed to property owners within the BGHAD service territory. The District receives its share of this tax in accordance with a prescribed schedule. Annual revenues of the BGHAD are allocated first to address expected annual expenses associated with routine hillside maintenance and landslide mitigation activities of the District. 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 forecasted major maintenance and capital repair projects. Although infrequent, these expenses can be substantial, requiring diligence in the planning process to assure that adequate reserves are maintained.

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 their missions. 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 can generally be expected to rise over time consistent with the Assessed Value of the CSA M-23 tax roles. Annual increases of Assessed Value are generally limited to an inflation factor not exceeding 2% under California Proposition 13 (1978). However, Assessed Values are adjusted to actual property inflation rates when property changes ownership, or when new construction is completed. When viewed in the long term perspective, Ad Valorem tax revenue can be expected to rise at rate equal to the property inflation rate, as eventually almost all property changes ownership over time and has its Assessed Value aligned with the market value of the property. An exception to always rising tax revenues can and does occur in very infrequent periods of rapid property value decline, such as what occurred during the Great Recession years of 2007-2012. History shows that Assessed Values can decline during such periods, and it also shows that Assessed Values do recover and converge with historical property value inflation rates over time.

During the recent period of revenue decline, the District put into effect certain austerity measures including 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). Ad-valorem tax revenues are expected to rise along with the now-underway housing value recovery. Accordingly, 100% inflation adjusted reserve fund contributions are planned to resume in the 2015-2016 fiscal year, and continue to rise consistent with property inflation rates in the ensuing years. These expected Reserve Fund contributions have been included in the Reserve Fund forecast included in this report.

EXISTING RESERVES

BGHAD's Reserve Fund is invested by the District Treasurer in compliance with State law. Current estimates are that the balance of the Reserve Fund will be $4,365,000 at the end of the 2012-2013 fiscal year. These funds have been set aside for the repair and replacement of the Districts assets and future landslides. Accordingly, these funds are not available for payment of other District obligations.

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 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 corresponds with the assumed 3% inflation rate. If the inflation rate rises, some of the increase in costs will 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 BGHAD project experience, and other public infrastructure maintenance and replacement projects in the San Francisco bay area.

SCOPE

This study is aligned with the District's fiscal year and forecasts capital project expenditures and needed Reserve Funds from 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 BGHAD infrastructure assets. These assets wear out over time and need to have 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 BGHAD 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 BGHAD's service territory are required to remain serviceable in order for BGHAD to achieve its mission. These assets include B-58 ditches, subdrain systems, other storm drain system components, retention basins, horizontal drains, piezometers and debris benches. Some of these assets are owned by the BGHAD, 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 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.

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 component of the Blackhawk development's hillside erosion protection and storm water runoff collection system. The District maintains approximately 63,500 linear feet, or over 12 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 proper function the District believes to be critical to maintaining slope stability. Newer less expensive technologies provide a method of extending the life of certain concrete ditches by lining them. The District intends to apply these technologies in appropriate locations.

B-58 DITCHES

SUBDRAINS

SUBDRAINS

A complex network of subdrains exists within the BGHAD service territory. Most of these subdrains were installed by the original developer when the original mass grading operations were underway, as the neighborhoods of Blackhawk were being developed. Some additional subdrains have been installed during slope repair operations under the direction of the District during the subsequent years.

Early subdrain installations were completed with little or no documentation identifying their locations. Many 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. BGHAD plans to continue to monitor the outflows of the known subdrain outlet locations, which currently number 104.

When subdrain outlet water flow yields begin to diminish, the District responds by cleaning the subdrain system to restore functionality. In certain situations where subdrain systems are not accessible for cleaning, the need for installation of 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 a continual maintenance item for the 104 known subdrain networks in its service territory.

OTHER STORM WATER COLLECTION SYSTEM COMPONENTS

The District maintains approximately 200 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, the District maintains in excess of 16,000 lineal feet of associated storm drain pipe. The proper functionality of the storm drain pipes is required for timely conveyance of storm water away from the catch basin inlets and to larger neighborhood water collection arteries, which are owned or maintained by others.

The ownership of each of these Storm Water Collection System Components resides with the underlying property owners.

RETENTION BASINS

Within the District's service territory there are seven (7) retention basins. Four (4) of these retention basins have been integrated into Blackhawk Country Club water features. Three (3) retention basins are used for storm water retention purposes only. During very intense rainstorms, these retention basins collect and retain excessive storm water, limiting outflows to volumes consistent with the capacities of the larger downstream storm drainage system.

The District shares the maintenance responsibilities of the four (4) dual purpose retention basins with the Blackhawk Country Club and the Blackhawk Homeowners Association. The Contra Costa Public Works Department has sole responsibility for the maintenance of the other three (3) Retention Basins. Major maintenance provided by the District to the four (4) dual purpose Retention Basins has historically included removing silt and undertaking other measures to assure capacity. The ownership of each of these Retention Basins resides with the underlying property owners.

RETENTION BASINS

HORIZONTAL DRAINS

HORIZONTAL DRAINS

During the original Blackhawk development grading operations, and in the years since, 257 horizontal drains have been installed in natural slopes to lower groundwater and enhance slope stability. The District installs and maintains these horizontal drains as a key defense against saturation of critical slopes. Approximately 25% of the population of installed horizontal drains have, over the last 30 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 the horizontal drain.

PIEZOMETERS

The depth of ground water has a great influence on the stability of slopes. The District has installed roughly 100 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 20% loss of functionality of these piezometers over the last 30 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 piezometers.

PIEZOMETERS

DEBRIS BENCHES

Throughout BGHAD'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 some 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.

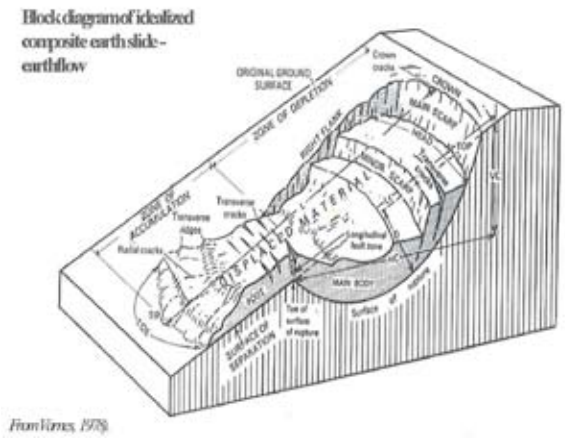
ADDITIONAL ASSETS MAY EXIST

Every effort has been made to list all of the assets that District owns and/or maintains in this Reserve Study. The District's actual 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. BGHAD'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.

Empirical data indicates that the number of landslides in the Danville area of Contra Costa County were shown to have increased dramatically after the intensity of the rainfall rose above 3.5 inches per day [1]. Therefore the criterion used in this Reserve Study for intense rainfall initiated hazards is rainfall in excess of 3.5 inches in a day.

In order to develop a reasonable return period for unusually wet winter (El Nino) rain initiated landslides within the BGHAD service territory, an evaluation was performed. Historical records at Blackhawk 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]. Therefore, the criterion used in this Reserve Study 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 Blackhawk area is 19.0 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 6 year interval, and that rainfall in excess of 1.5 times the MSP can be expected to recur on a 10 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 BGHAD service territory includes 105 historical landslides that were not improved or removed during the Blackhawk development grading operations that pose the greatest risk of becoming unstable in the event of a major earthquake [18]. The BGHAD 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 BGHAD 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 BGHAD 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 to landsliding, 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 BGHAD service territory [12].

A swarm of earthquakes of smaller magnitude more local to the BGHAD service territory occurred in San Ramon in 2002. The largest earthquake in this swarm generated a peak acceleration of approximately 0.04g in the BGHAD service territory [13,14,15]. There is no evidence from that either of these two earthquake sequences caused any new land sliding in the BGHAD service territory.

Lacking direct BGHAD experience correlating ground motion in the Blackhawk areas to BGHAD 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 a landslide. 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 BGHAD'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 BGHAD'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 BGHAD 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 every 78 years. As the science of predicting earthquakes improves over time, the return rate will be adjusted in future Reserve Study updates to reflect such information.

FLOOD INITIATED HAZARDS

In addition to slope stability challenges that are predicted to occur directly from rain fall on the slopes within the BGHAD 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 would be expected to increase the likelihood and severity of land sliding.

The US Geologic Survey (USGS) has established 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 the USGS to be underwater following a 100 year flood indicates that the areas within the BGHAD service territory involved do not overlap with the mapped toes of historic slides [19]. Accordingly, this Reserve Study does not anticipate the need for additional reserves for Flood Initiated Hazards.

SEVERE EVENT EMERGENCY RESPONSE

Corresponding with severe rain events, or following anticipated large scale seismic events, the BGHAD 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 BGHAD's Preventive Maintenance program.

Severe Event Emergency Response activities of the BGHAD 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, BGHAD 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 BGHAD 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 BGHAD service territory was studied as part of the Reserve Study update. 105 historical landslides, which have not been repaired, have been grouped into three different repair cost categories [18]. The categories and their criteria being:

1. Low cost – historical slides areas with slopes of less than 5:1; historical slide 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 below or on the mapped slide area.
2. Average cost – historical 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 – historical 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, half of all landslides will be more expensive to repair than the mean and half 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. BGHAD'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 BGHAD owned/ maintained infrastructure, the mean landslide repair cost for the average 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 6 year return interval
2. Wet Season (el Niño) event exceeding 1.5 times the mean annual precipitation with a 10 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 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 [18]. Based on this historical data, this Reserve Study update is based on repairing one average cost landslide per intense rainfall event. The most recent times that annual rainfall exceeded 1.5x MSP in Danville were the years 1998, 1996, 1995, and 1983. Four times in the past 40 years, which is consistent with a 10 year average return period. Historical records of the District indicate that seven (7) new landslide repairs were undertaken in the mid 1990's. These are assumed to be correlated to the three Wet Season (El Nino) initiating events during those years. Based on this historical data, this Reserve Study update is based on repairing three average cost landslides per Wet Season (El Nino) year.

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 BGHAD service territory from this earthquake. The District maintains a data base of historic slides mapped in its service territory. This list indicates that 105 such slides that have not been repaired. 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 historic 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 historical landslides will need repairs following an earthquake that generates a greater than 0.15g horizontal ground motion inside of the BGHAD service territory. Based on the relative number of each that exists in the BGHAD service territory, twenty-one (24) landslides will be assumed to require repair. This will include seven (7) high cost landslide repairs, three (3) average cost landslide repairs, and fourteen (14) low cost landslide repairs. Based on the previously developed cost of each, these repairs would be expected to total $9,259,000 in 2013 dollars.

CONCLUSIONS AND RECOMMENDATIONS

The Reserve Fund cost forecast for the next 40 years are shown on the following 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 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 actual BGHAD expenditures and account balances.

Lastly, it is noted that the actual dollar amounts available in BGHAD'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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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 Blackhawk Geological Hazard District's Service Territory, published by ATI Architects and Engineers, dated March 8, 2013

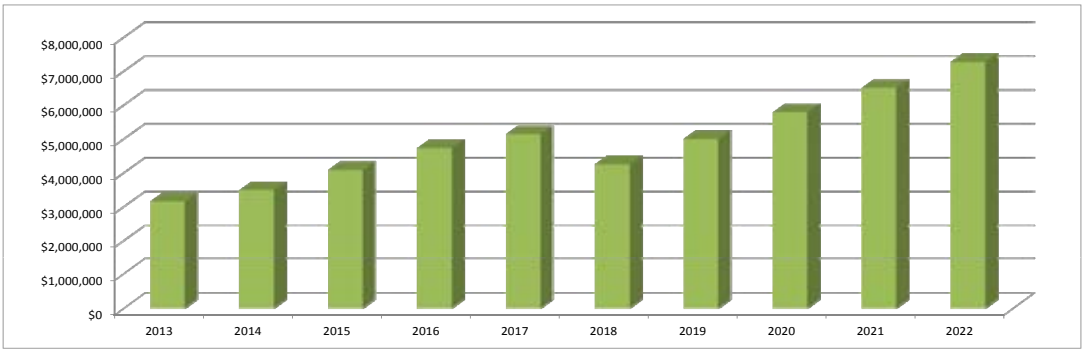
19. 100 Year Flood Map for Blackhawk, California, published by USGS

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
				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 - Phase 1 Replacement														
5 yr remaining life	$118,800	30	5						$137,722					
35 yr remaining life	$1,128,010	60	35 **											
2 - Phase 2 Replacement														
5 yr remaining life	$136,680	30	5						$158,450					
20 yr remaining life	$252,280	45	20											
35 yr remaining life	$1,756,440	60	35 **											
3 - Phase 3 Replacement														
35 yr remaining life	$1,103,450	60	35 **											
SUBDRAINS:														
4 - Major maintenance														
5 yr remaining life	$130,000	70	5							$155,227				
15 yr remaining life	$260,000	70	15											
25 yr remaining life	$260,000	70	25											
35 yr remaining life	$260,000	70	35 **											
STORM DRAIN PIPING/SYSTEMS:														
5 - Phase 1 Replacement *	$205,200	75	50											
6 - Phase 2 Replacement *	$415,400	75	53											
7 - Phase 3 Replacement *	$272,000	75	55											
RETENTION BASINS:														
8 - Major Maintenance	$32,000	3	3				$34,967			$38,210			$41,753	
HORIZONTAL DRAINS:														
9 - Major Cleaning														
5 yr remaining life	$77,100	50	5							$92,061				
15 yr remaining life	$154,200	50	15											
25 yr remaining life	$154,200	50	25											
35 yr remaining life	$154,200	50	35											
PIEZOMETERS:														
10 - Replacement	$2,400,000													
5 yr remaining life	$120,000	50	5							$143,286				
15 yr remaining life	$240,000	50	15											
25 yr remaining life	$240,000	50	25											
35 yr remaining life	$240,000	50	35											
DEBRIS BENCHES:														
SETTLEMENT MONITORS:														
11 - Major Maintenance	$32,000	3	3				$34,967			$38,210			$41,753	
SEVERE EVENT RESPONSE														
12 - Response	$45,000	6	3					$50,648						$60,476
EXCESSIVE RAINFALL HAZARD:														
13 - 3.5" in 24 hour period	$969,000	6	6							$1,157,037				
14 - 1.5 x average	$1,615,000	10	1		$1,663,450									
MAJOR EARTHQUAKE HAZARD														
15 - > .15g horizontal force *	$9,259,000	78	44											
TOTAL EXPENDITURES	**$22,029,960**				**$1,663,450**	**$0**	**$69,935**	**$50,648**	**$296,171**	**$1,624,031**	**$0**	**$0**	**$83,505**	**$60,476**

* 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 years 31-40 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				$314,150	$323,575	$666,563	$686,560	$707,157	$728,372	$750,223	$772,730	$795,912	$819,789
Per Unit Per Month (2200 units)				$11.90	$12.26	$25.25	$26.01	$26.79	$27.59	$28.42	$29.27	$30.15	$31.05
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%)				$3,154	$3,481	$4,082	$4,722	$5,138	$4,247	$5,002	$5,781	$6,500	$7,266
ENDING BALANCE				**$3,153,854**	**$3,480,909**	**$4,081,620**	**$4,722,255**	**$5,138,379**	**$4,246,967**	**$5,002,192**	**$5,780,703**	**$6,499,609**	**$7,266,188**

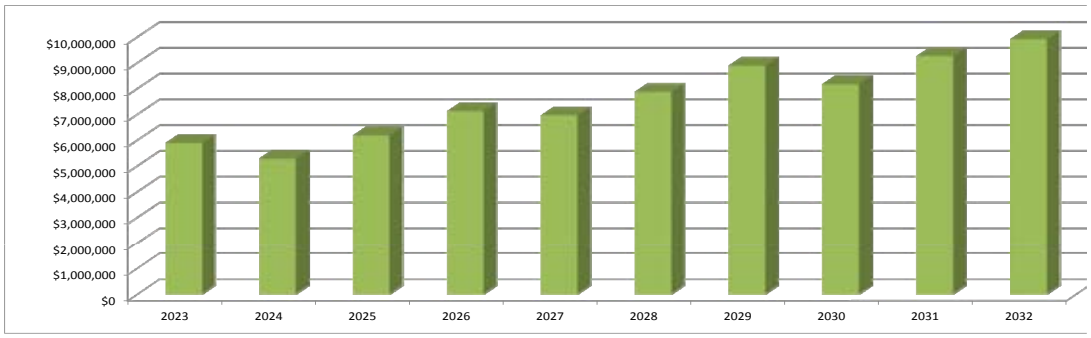


PROJECTED EXPENDITURES (2023-2032)

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
				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 - Phase 1 Replacement														
5 yr remaining life	$118,800	30	5											
35 yr remaining life	$1,128,010	60	35 **											
2 - Phase 2 Replacement														
5 yr remaining life	$136,680	30	5											
20 yr remaining life	$252,280	45	20											$455,646
35 yr remaining life	$1,756,440	60	35 **											
3 - Phase 3 Replacement														
35 yr remaining life	$1,103,450	60	35 **											
SUBDRAINS:														
4 - Major maintenance														
5 yr remaining life	$130,000	70	5											
15 yr remaining life	$260,000	70	15						$405,072					
25 yr remaining life	$260,000	70	25											
35 yr remaining life	$260,000	70	35 **											
STORM DRAIN PIPING/SYSTEMS:														
5 - Phase 1 Replacement *	$205,200	75	50											
6 - Phase 2 Replacement *	$415,400	75	53											
7 - Phase 3 Replacement *	$272,000	75	55											
RETENTION BASINS:														
8 - Major Maintenance	$32,000	3	3			$45,624			$49,855			$54,478		
HORIZONTAL DRAINS:														
9 - Major Cleaning														
5 yr remaining life	$77,100	50	5											
15 yr remaining life	$154,200	50	15						$240,239					
25 yr remaining life	$154,200	50	25											
35 yr remaining life	$154,200	50	35											
PIEZOMETERS:														
10 - Replacement	$2,400,000													
5 yr remaining life	$120,000	50	5											
15 yr remaining life	$240,000	50	15						$373,912					
25 yr remaining life	$240,000	50	25											
35 yr remaining life	$240,000	50	35											
DEBRIS BENCHES:														
SETTLEMENT MONITORS:														
11 - Major Maintenance	$32,000	3	3			$45,624			$49,855			$54,478		
SEVERE EVENT RESPONSE														
12 - Response	$45,000	6	3							$72,212				
EXCESSIVE RAINFALL HAZARD:														
13 - 3.5" in 24 hour period	$969,000	6	6			$1,381,562						$1,649,658		
14 - 1.5 x average	$1,615,000	10	1		$2,235,538									
MAJOR EARTHQUAKE HAZARD														
15 - > .15g horizontal force *	$9,259,000	78	44											
TOTAL EXPENDITURES	**$22,029,960**				**$2,235,538**	**$1,472,811**	**$0**	**$0**	**$1,118,932**	**$72,212**	**$0**	**$1,758,613**	**$0**	**$455,646**

* 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 years 31-40 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
RESERVE CONTRIBUTION				$844,383	$869,714	$895,806	$922,680	$950,360	$978,871	$1,008,237	$1,038,484	$1,069,639	$1,101,728
Per Unit Per Month (2200 units)				$31.98	$32.94	$33.93	$34.95	$36.00	$37.08	$38.19	$39.34	$40.52	$41.73
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%)				$5,881	$5,283	$6,185	$7,115	$6,953	$7,868	$8,885	$8,173	$9,252	$9,908
ENDING BALANCE				**$5,880,913**	**$5,283,100**	**$6,185,090**	**$7,114,885**	**$6,953,266**	**$7,867,793**	**$8,884,915**	**$8,172,959**	**$9,251,849**	**$9,907,839**

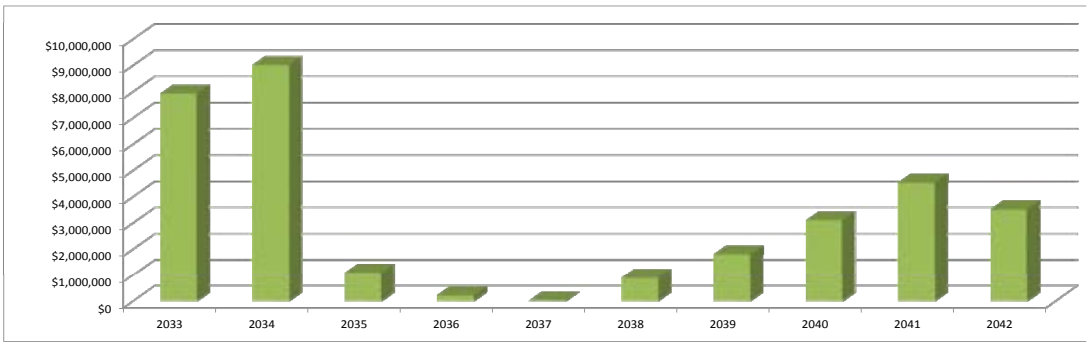


PROJECTED EXPENDITURES (2033-2042)

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
				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 - Phase 1 Replacement														
5 yr remaining life	$118,800	30	5											
35 yr remaining life	$1,128,010	60	35 **											
2 - Phase 2 Replacement														
5 yr remaining life	$136,680	30	5											
20 yr remaining life	$252,280	45	20											
35 yr remaining life	$1,756,440	60	35 **											
3 - Phase 3 Replacement														
35 yr remaining life	$1,103,450	60	35 **											
SUBDRAINS:														
4 - Major maintenance														
5 yr remaining life	$130,000	70	5											
15 yr remaining life	$260,000	70	15											
25 yr remaining life	$260,000	70	25						$544,382					
35 yr remaining life	$260,000	70	35 **											
STORM DRAIN PIPING/SYSTEMS:														
5 - Phase 1 Replacement *	$205,200	75	50						$107,411					
6 - Phase 2 Replacement *	$415,400	75	53							$447,924				
7 - Phase 3 Replacement *	$272,000	75	55								$302,095			
RETENTION BASINS:														
8 - Major Maintenance	$32,000	3	3		$59,529			$65,049			$71,081			$77,672
HORIZONTAL DRAINS:														
9 - Major Cleaning														
5 yr remaining life	$77,100	50	5											
15 yr remaining life	$154,200	50	15											
25 yr remaining life	$154,200	50	25						$322,861					
35 yr remaining life	$154,200	50	35											
PIEZOMETERS:														
10 - Replacement	$2,400,000													
5 yr remaining life	$120,000	50	5											
15 yr remaining life	$240,000	50	15											
25 yr remaining life	$240,000	50	25						$502,507					
35 yr remaining life	$240,000	50	35											
DEBRIS BENCHES:														
SETTLEMENT MONITORS:														
11 - Major Maintenance	$32,000	3	3		$59,529			$65,049			$71,081			$77,672
SEVERE EVENT RESPONSE														
12 - Response	$45,000	6	3			$86,225						$102,957		
EXCESSIVE RAINFALL HAZARD:														
13 - 3.5" in 24 hour period	$969,000	6	6					$1,969,777						$2,352,017
14 - 1.5 x average	$1,615,000	10	1		$3,004,376									
MAJOR EARTHQUAKE HAZARD														
15 - > .15g horizontal force *	$9,259,000	78	44				$9,136,719							
TOTAL EXPENDITURES	**$22,029,960**				**$3,123,435**	**$86,225**	**$9,136,719**	**$2,099,876**	**$1,477,160**	**$447,924**	**$444,258**	**$102,957**	**$0**	**$2,507,362**

* 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 years 31-40 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				$1,134,780	$1,168,823	$1,203,888	$1,240,004	$1,277,205	$1,315,521	$1,354,986	$1,395,636	$1,437,505	$1,480,630
Per Unit Per Month (2200 units)				$42.98	$44.27	$45.60	$46.97	$48.38	$49.83	$51.33	$52.86	$54.45	$56.08
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%)				$7,927	$9,019	$1,087	$227	$27	$896	$1,808	$3,104	$4,546	$3,523
ENDING BALANCE				**$7,927,111**	**$9,018,729**	**$1,086,985**	**$227,340**	**$27,412**	**$895,904**	**$1,808,441**	**$3,104,225**	**$4,546,276**	**$3,523,067**

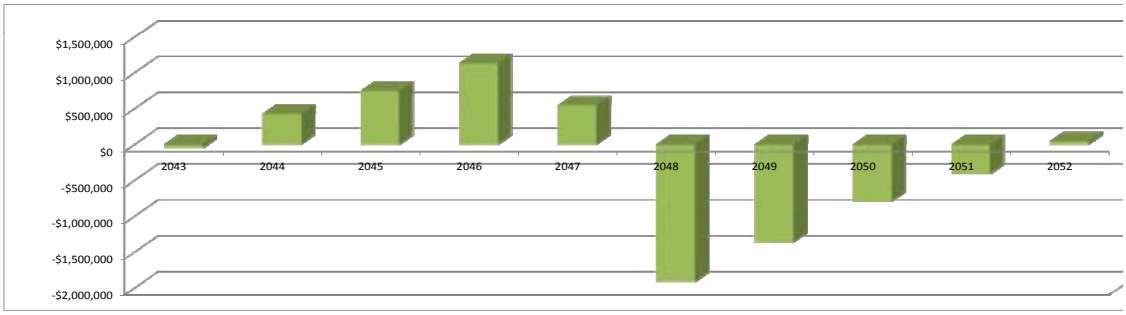


PROJECTED EXPENDITURES (2043-2052)

RESERVE COMPONENTS	Current Repair/Replace Cost	Estimated Useful Life (yr.)	Estimated Remaining Life (yr.)	Fiscal Year July 1 ... June 30...	(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
				0.03	2.50	2.58	2.65	2.73	2.81	2.90	2.99	3.07	3.17	3.26
B-58 DITCHES														
1 - Phase 1 Replacement														
5 yr remaining life	$118,800	30	5											
35 yr remaining life	$1,128,010	60	35 **		$282,012	$290,472	$299,186	$308,162	$317,406	$326,929	$336,737	$346,839	$357,244	$367,961
2 - Phase 2 Replacement														
5 yr remaining life	$136,680	30	5											
20 yr remaining life	$252,280	45	20											
35 yr remaining life	$1,756,440	60	35 **		$439,124	$452,298	$465,867	$479,843	$494,238	$509,065	$524,337	$540,067	$556,269	$572,957
3 - Phase 3 Replacement														
35 yr remaining life	$1,103,450	60	35 **		$275,871	$284,148	$292,672	$301,452	$310,496	$319,811	$329,405	$339,287	$349,466	$359,950
SUBDRAINS:														
4 - Major maintenance														
5 yr remaining life	$130,000	70	5											
15 yr remaining life	$260,000	70	15											
25 yr remaining life	$260,000	70	25											
35 yr remaining life	$260,000	70	35 **		$65,002	$66,952	$68,961	$71,030	$73,160	$75,355	$77,616	$79,944	$82,343	$84,813
STORM DRAIN PIPING/SYSTEMS:														
5 - Phase 1 Replacement *	$205,200	75	50											
6 - Phase 2 Replacement *	$415,400	75	53											
7 - Phase 3 Replacement *	$272,000	75	55											
RETENTION BASINS:														
8 - Major Maintenance	$32,000	3	3				$84,875			$92,745			$101,345	
HORIZONTAL DRAINS:														
9 - Major Cleaning														
5 yr remaining life	$77,100	50	5											
15 yr remaining life	$154,200	50	15											
25 yr remaining life	$154,200	50	25											
35 yr remaining life	$154,200	50	35						$433,898					
PIEZOMETERS:														
10 - Replacement	$2,400,000													
5 yr remaining life	$120,000	50	5											
15 yr remaining life	$240,000	50	15											
25 yr remaining life	$240,000	50	25											
35 yr remaining life	$240,000	50	35						$675,327					
DEBRIS BENCHES:														
SETTLEMENT MONITORS:														
11 - Major Maintenance	$32,000	3	3				$84,875			$92,745			$101,345	
SEVERE EVENT RESPONSE														
12 - Response	$45,000	6	3					$122,936						$146,792
EXCESSIVE RAINFALL HAZARD:														
13 - 3.5" in 24 hour period	$969,000	6	6							$2,808,432				
14 - 1.5 x average	$1,615,000	10	1		$4,037,630									
MAJOR EARTHQUAKE HAZARD														
15 - > .15g horizontal force *	$9,259,000	78	44											
TOTAL EXPENDITURES	**$22,029,960**				**$5,099,639**	**$1,093,869**	**$1,296,435**	**$1,283,422**	**$2,304,525**	**$4,225,081**	**$1,268,094**	**$1,306,137**	**$1,548,011**	**$1,532,473**

* 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 years 31-40 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				$1,525,049	$1,570,800	$1,617,924	$1,666,462	$1,716,456	$1,767,950	$1,820,988	$1,875,618	$1,931,886	$1,989,843
Per Unit Per Month (2200 units)				$57.77	$59.50	$61.29	$63.12	$65.02	$66.97	$68.98	$71.05	$73.18	$75.37
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%)				-$52	$426	$748	$1,132	$545	-$1,914	-$1,363	-$794	-$411	$47
ENDING BALANCE				**-$51,575**	**$425,782**	**$748,020**	**$1,132,192**	**$544,668**	**-$1,914,378**	**-$1,362,847**	**-$794,160**	**-$410,696**	**$46,721**



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

Blackhawk Geologic Hazard Abatement District
4125 Blackhawk Plaza Circle, Suite 175 • Danville, CA 94506
Phone: 925.964.0823