



Outlook

Public Comment re MIRP

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To BCDC Public Comment <publiccomment@bcdca.gov>

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 1 attachment (3 MB)

20260729 MIRP Impact on Water Quality.pdf;

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Hi,

Attached please find a Public Comment regards the MIRP.

Thank you.

MIRP Impact
on
Water Quality
in
Gashouse Cove

July 2026

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Introduction

PG&E and San Francisco's Recreation and Park Department (RPD) submitted a permit application to BCDC for the Marina Improvement and Remediation Project (MIRP), a renovation of the small-craft harbor in Gashouse Cove. The MIRP extends the existing breakwater to better protect berths in the northern half (North) and converts the southern half (South) into a recreation area for kayaks, stand-up paddleboards, and the like. BCDC staff is currently reviewing the application. It is expected to be heard by the full Commission before the end of 2026.

The MIRP stems from a 20-year dispute between RPD and PG&E over toxic chemicals beneath Gashouse Cove. PG&E is arguably liable for the chemicals but RPD was unable to prevail in court so they made a financial agreement instead. PG&E will fully fund the project in exchange for RPD permanently storing most of the chemicals. The numbers are roughly \$190M split 50/50 between remediation and improvements, and 15% chemicals removed versus 85% chemicals stored. The configuration of chemical storage is germane to BCDC because it dedicates Bay resources to an undesirable use. The conversion of a boat harbor into a recreation area is also germane because BCDC highly values public access. The tradeoffs involve assumptions, beliefs, wants vs needs, a contested block, predictions, and practical considerations. These subjects have been addressed in a separate report to BCDC.

Independent of Bay-resource/greater-access questions, BCDC has another interest in the project: water quality. The Bay Plan contains policies specific to water quality. The MIRP will make changes that have direct impacts – positive and negative impacts – to water quality in Gashouse Cove. The impacts can be evaluated technically with some certainty. Less quantifiable, Gashouse Cove has two aggravating conditions that must be included in any decision involving water quality because the conditions are real and involve risk. The two are the chemicals from former MGPs and the Laguna Street CSO. All these are analyzed in this report.

The conclusion is that the MIRP has a net negative effect on water quality. BCDC must reject the application or place significant conditions on its approval. Otherwise, BCDC will violate its own water quality policies.

Factors Affecting Water Quality

Gashouse Cove shares characteristics common to all tidal inlets with no freshwater source: tides are the only mechanism of exchange. Tidal inlets used as marinas experience reduced surface flow and circulation caused by moored boats and floating docks which block sunlight, suppress wind-driven surface mixing, create stagnant zones underneath, accelerate oxygen depletion, and grow algae beneath the docks. These are baseline challenges against which the effects of the MIRP is evaluated.

As shown in Figure 1, Gashouse Cove is a partially enclosed 12-acre salt-water inlet with no freshwater source protected from San Francisco Bay by manmade structures on all sides except for a NE facing gap, mouth, or opening, between its breakwater and Fort Mason's land mass (excluding its piers). Bathymetry shown in Figure 2 illustrates the shallowness of Gashouse Cove, called East Harbor in the figure. The existing opening, approximately 325' wide, is illustrated in Figure 3.

Tidal flushing is the main driver affecting circulation and exchange, and, ultimately, water quality in Gashouse Cove. Tide swings near Fort Mason are typically 5' to 6' with king tide swings approaching 9'. Interior features including floating docks and corners are primary factors affecting surface currents. Swells from the NE plague Gashouse Cove berths but have a positive influence on circulation. The long-shore sediment transport seen along West Harbor's outer jetty is not likely to be a factor at the entrance to Gashouse Cove.

The MIRP is illustrated by the applicants in Figure 4. A simplified version is Figure 5 and Figures A1 and A2 of the Attachment show dimensions and introduce some of the terminology used in this report. A major factor introduced by the MIRP is a 180' breakwater extension running north-to-south off the eastern tip of the existing breakwater. The breakwater extension will make the swells from the NE less of a factor on circulation. Another major factor is the 4' MLLW design depth of South versus the 8' MLLW design depth of North and associated bottom contours.¹ Overall, except for the probability of increased scouring near the opening, it is expected that the MIRP will result in Gashouse Cove having more gentle tidal fluctuations than it currently experiences. Less energetic exchanges are not good for water quality because it results in less mixing and thus less undesirable constituents are removed with the tide.

Positive and negative projections can be made for the effect of the MIRP on water quality. In general, water quality would benefit from reducing South to 4' MLLW because the tide exchanges a larger fraction when there is less volume to exchange. On the other hand, water quality suffers from the breakwater extension because it blocks circulation and creates new corners. Reducing South to 4' MLLW is a double edged sword: as described

above it benefits by reducing overall volume but it harms by creating a difficult-to-clean trough in North. These dueling effects are addressed in the next section.

MIRP Impacts on Water Quality

Reduced Opening to Gashouse Cove

The openings with the existing breakwater, and with MIRP's 180' extension off its eastern tip, are depicted in Figures 3 and 6, respectively. Boats traverse north-south through the channel. Tidal ebbs and flows, however, also travel east-west (without MIRP) or northeast-southwest (with MIRP) through the opening. That's because Pier 1 blocks boats but does not block water flow. Tidal waters enter and exit Gashouse Cove between the tip of either breakwater and landfall at the intersection of Fort Mason Pier 1 and Building A. Fort Mason Pier 1 is a raised structure on piles; water flows freely beneath it at all tidal stages. The breakwater is impermeable — no water crosses it. Figure 7 is a general representation of the tidal flows and ebbs with the MIRP.

Although the MIRP reduces the opening by almost half, roughly 325 feet to 170 feet, it does not prevent Gashouse Cove from equilibrating with the tide. At all times, the sea level inside the cove is the same as the sea level in the Bay. This fact is important for the tidal prism analysis discussed below.

Baffling of Surface Water Flow

Surface water at flood tide enters at the opening and fans north, south, and west into Gashouse Cove. With the MIRP, the dense parallel array of approximately 165 finger slips shown in Figure 8 baffles surface flow progressively as water moves away from the opening. This reduces momentum and creates lower-circulation zones in the western and northern corners of North, farthest from the channel. Surface water reaches both North and South directly from the opening. The Visitor Dock running east-west across the middle of the cove does not obstruct surface flow near the opening but it inhibits surface flow between North and South. Overall, North will suffer the most from the poor exchange of surface water. North also suffers from the problems associated with moored boats and floating docks mentioned earlier.

Limiting Deep Water Exchange

The MIRP will dredge and cap the channel to 10' MLLW (design depth). The MIRP will cap but not dredge the bottom under Pier 1. Finished elevations under Pier 1 are not included

in the application or are not easily discernable from it. The east side (right hand side) of Figure 9 implies that the elevations under Pier 1 and at the bottom of the channel will be roughly the same, but the two will be separated by a small curb. Figure 10 implies that the channel is a trench. It's possible that this detail will not be known until it's built.

Regardless, it's evident that the deepest water entering Gashouse Cove will be constrained by the MIRP's bottom contours. While the Channel is at 10' MLLW, North (including berthing areas A and B) will be dredged to a design elevation of 8' MLLW. South will not be dredged but has a design elevation of 4' MLLW.² These three depths converge simultaneously at the mouth.

Dense, cold Bay water is capable of holding more dissolved oxygen than warmer surface water.³ During flood, this oxygen-rich Bay water traveling along the channel floor at 10' MLLW encounters a 6-foot vertical rise at the entry to South. That bottom water cannot enter South. The 2-foot vertical rise into North allows a greater portion of the rich bottom water in but it still cannot enter South because it encounters a 4-foot rise there. The result is that North sees some and South sees none of the deep water meaning the stepped bottom contour has a negative effect on water quality.

Creating a Trough

The MIRP's stepped bottom contour is detrimental to water quality in more critical way. Figures 11 through 20 describe the steps in detail gleaned from the MIRP application and related figures. The steps combine with the existing breakwater and breakwater extension to create a 850' x 300' x 4' deep trough under North's upper layers. A 120' opening to the channel means the trough is not fully enclosed... but it's still a bad design for water quality. The elongated shape, approximately 3:1, and baffling at the surface inhibits circulation patterns from organizing during flood and quiets flow. The trough will drain during ebb but it will not be draining well-mixed waters.

Prop Wash Anomaly

An exception is identified in Figure 21. While the rest of South silted up from years of neglect, prop wash from larger vessels using the fuel dock etched a channel parallel to the existing fuel dock. The existence of the prop wash channel makes the step-up from channel to South appear, in Figure 20, slightly less than the 6' design delta. It's a temporary anomaly with no effect on this analysis. It will disappear soon after the fuel dock is decommissioned.

Tidal Prism Analysis

The positive and negative projections about the MIRPs effect on water quality are examined more rigorously in this and the next section. The goal is to prove, quantifiably and repeatably, which design is better at moving pollution out of Gashouse Cove and into the Bay.

Tidal prism analysis uses the ratio of tidal prism to basin volume as a first-order approximation of cleaning efficiency. Tidal prism is the volume of water that comes in on each flood; it is the same as the volume of water that goes out on each ebb; it is the plan area of the basin times the change in height of the tide. Basin volume is the plan area of the basin times the depth of the basin. Tidal prism analysis assumes that clean water coming in with the flood tide mixes with dirty water in the basin, dilutes it, and then the same volume of now-diluted dirty water goes out with the ebb tide. The process repeats and the basin gets cleaner with each cycle. The ratio is a figure of merit. The larger the ratio the more efficient the alternative is at cleaning contaminants out of the basin. If the ratio is one, then one-half the basin's water is exchanged each cycle.

From the attachment, the ratio with MIRP is 93.5% and without MIRP it is 72.0%. The MIRP wins hands-down! The reason is straightforward. The tidal prism is identical (the amount of water that comes and goes with each tide is the same with and without the MIRP) but the basin volume is not the same. The MIRP reduced basin volume by changing South from 8' MLLW to 4' MLLW. This change results in the MIRP delivering a real, positive benefit to water quality.

The fact that MIRP wins in this analysis reflects a truism of tidal inlets: water quality of any inlet can be improved by making the inlet shallower. Make the thing you want to clean smaller and it's easier to clean.

The advantage MIRP gains by reducing Gashouse Cove's volume has a true and positive effect on water quality in all scenarios. However, a tidal prism analysis alone does not paint the whole picture. It does not include the other two factors mentioned earlier: corners and reduced circulation caused by the breakwater extension and the difficult-to-clean trough resulting from the stepped bottom. For a more complete analysis, turn to the multi-box sub-zone simulation.

Multi-Box Sub-Zone Simulation

A model of Gashouse Cove's spatial geometry is constructed and a multi-box sub-zone simulation used to quantify the effect of different basin configurations on water quality. A comparison is made between the MIRP and Gashouse Cove's original marina design. The

goal is the same: determine which design is better at moving pollution out of Gashouse Cove and into the Bay. Details of the model, simulation, and results are in the attached “Comparative Performance Analysis.”

For verification, the tidal prism analysis is straightforward and requires no special skills or tools to replicate. The less familiar multi-box sub-zone simulation is explained in the attachment. It can be verified or modified by downloading three files: the simulation engine [\[Link\]](#); the input template [\[Link\]](#); and “how to” instructions [\[Link\]](#). If needed, several Ais understand these files and are able to repeat the results or generate new results as requested.

The model keeps South (S) and the channel (C) intact but divides North first into northwest (NW) and northeast sections and then divides northeast into north (NEN) and south (NES) sections. These divisions spotlight the changes made by MIRP and the role each section plays in the cleaning process. The horizontal sections are then divided in 2’ vertical increments from MLLW downward to observe how different levels perform. The net result is a 21-box model. The simulation adds dye to one box at t=0 (dye is a substitute for dirty water) and then mathematically determines the amount of dye in all 21 boxes every 15 minutes for 3 weeks as the tide forces water in and out of the system and each box behaves as it must according to the laws of physics.

The simulation results reverse the finding in the tidal prism analysis. MIRP loses! Not every time, but most -- the MIRP’s reduction of basin volume still gives it an advantage in one scenario. This multi-box analysis looks deeper into the effect of the MIRP’s two major changes (breakwater extension, stepped bottom) and finds that the MIRP is bad for water quality. The disadvantage of cutting off NES from the Bay and creating a trough under North outweighs the reduction of basin’s volume.

The attachment describes these tradeoffs in greater detail. Of particular interest are the concept of crossover and NW4. Crossover illustrates the internal workings of spatial geometries which result in long-term losses for short-term gains. NW4, the lowest layer in the northwest section, is the perennial bad spot -- both with and without the MIRP – but the trough makes it worse.

A few clarifications about the simulation: 1) it was set up as contest and accurately determines which alternative is better or worse but it is not designed to predict real-world cleaning times,⁴ 2) it treats every box as fully mixed each time step which, like the tidal prism analysis, is a simplification⁵, and 3) it will not model mixing, which are caused by local eddies and shear forces in the real-world, without setting mixing coefficients (m)⁶.

Chemicals from Former MGPs

The Water Board determined the MIRP protects health and the environment.⁷ Still, hazardous chemicals from former MGPs beneath the sediment are in contact with pore water and some inevitably make their way into surface water. The chemicals are 100 years old; they are not soluble but may be suspended in water and travel through advection or diffusion.⁸ In high concentrations, the chemicals form coal tar which humans can see, feel, smell. In low concentrations, the chemicals are only detectable by sampling and laboratory analysis – but they are still hazardous. PG&E warns Marina residents about the unseen danger: “... **some of which may not be visible to the naked eye, and may need testing to determine if these materials are present... some of which may reasonably be expected to be carcinogens.**”⁹ The chemicals are heterogeneously distributed in a large section of the Marina.¹⁰ They are in, under, and all-around Gashouse Cove. They have been observed visibly as black blobs bubbling to the surface [[Video 1](#)]¹¹ [[Video 2](#)].¹² The blobs turn into sheens and then disappear. The phenomena has been formally observed and reported to the Water Board quarterly since 2017.¹³ This is the important part: when the sheens disappear, the chemicals do not cease to exist — they remain in the water column until they eventually make their way out to sea. BCDC must grasp the difference between the treatment of what is seen and the treatment of what remains unseen for it to fulfill its responsibilities in this matter.

The IRM

Figure 23 shows a skirted boom in Gashouse Cove. It’s an example of different treatments for seen and unseen problems by institutions - institutions with a poor track record for addressing problems simply and directly.

The bubbling of black blobs and sheens into Gashouse Cove was first observed by an unknown person who owned a boat docked nearby . In 2012, he sent Video 1 to RPD who sent it to the Water Board. The bubbling was ignored at first and, when it was finally taken seriously, the Water Board was told the boat owner was a “troublemaker.” Four years later, 2016, a 15’ x 15’ reactive core mat was placed over the seep to stop the blobs and sheens from rising to the surface.¹⁴ The mat was to be an interim remediation measure, hence the term IRM, until “a permanent remedy begins in 2 years.”¹⁵ The skirted boom was installed after two attempts with the mat failed. The boom confines the blobs and sheens until they disappear. The boom may be considered successful in that no boat or shoreline has been fouled for the last ten years. Keep in mind, however, that it is the seen problem that is disappearing and not the unseen problem.

The unseen problem are the chemicals that were formerly in the blobs and sheens. They do not evaporate, are not eaten by microbes, and are not diminished in any way by being corralled inside a skirted boom. The chemicals disappear from view but continue to exist, diluted, inside the boom. In time, the chemicals migrate out of the boom and through Gashouse Cove to the Bay and then to the Pacific where no one cares anymore. Right or wrong, it's the way people have gotten rid of stuff they don't want for ages. Setting the moral question aside, the point is that the visible problem has been resolved but the invisible problem has not. The institutions involved have maintained the appearance of attention by monitoring and writing quarterly reports for 10 years. They have been dealing with the symptom and not the problem, the *unseen* problem. What will BCDC do?

The MIRP will dig a 100' by 100' hole under the IRM and remove approximately 10' of contaminated sediment and then cap and backfill the hole with low permeable material, and possibly sheeting, to the existing mudline. The purpose of the cap, backfill, and sheeting is to address "*the potential for migration of upland deeper groundwater and NAPL.*"¹⁶ The quote is an oblique reference to a very large hot spot under sediment and under upland soil, mostly westward of the IRM seep.¹⁷ This approach – save money by leaving chemicals in situ and, when necessary, place barriers between the chemicals and vulnerable populations – is a hallmark of PG&E remediations.¹⁸ The quote says groundwater *and* NAPL, but only NAPL will be held back – and that's not guaranteed. Groundwater can be redirected but cannot be stopped. Contaminated groundwater from the hot spot will make its way into the Gashouse Cove at some location. It is true that removing 3,700 cubic yards of sediment infused with harmful chemicals is addressing the problem, but the problem is so much bigger. Capping and backfilling the hole with low permeable material is tacitly admitting there's a lot more chemicals remaining. It's putting a finger in the dike and hoping for the best.

Like the skirted boom, MIRP's plan for the IRM is another illustration of different treatments for problems that can be seen and those that remain unseen. It might stop NAPL but it won't stop groundwater. PG&E has never been concerned with contaminated groundwater entering the Bay... because it's unseen. The company wouldn't test groundwater until a lawsuit forced it to do so. On the other hand, PG&E is motivated by blobs and sheens... because they're seen, they're embarrassing. The low permeable backfill and possible sheeting are PG&E's hope to eliminate the embarrassment. It might work and it might not. BCDC should heed these remarks for two reasons. First, the fact is there is a non-zero chance it doesn't work, the IRM didn't work. The reappearance of blobs and sheen means no Kayak/SUP area, no "greater public access," no way to utilize South as a boat harbor, a mudflat, and not just a mudflat but a toxic mudflat. Second, working or not there will always be unseen chemicals emanating from the chemical storage that BCDC will approve

with the MIRP.¹⁹ Those chemicals must travel as efficiently as possible from Gashouse Cove to the Bay and to the sea. That's part of what is being permitted whether it's explicit or not.

Permeable Reactive Barrier

As shown in Figures 24 and 25, the MIRP will install a permeable reactive barrier on Gashouse Cove's west and south shorelines. Unlike *low* permeable barriers used in engineered caps and IRM, which are designed to block water along with everything else, permeable barriers are designed to allow water to pass while blocking NAPL.

Similar to the IRM's reactive core mat – the remediation measure that failed – permeable reactive barriers are essentially large flat filters consisting of a layer of activated carbon sandwiched between two layers of cloth. Activated carbon is supposed to be good at absorbing NAPL, but NAPL in groundwater is evidently better at finding a pathway into the water column. That's why the IRM failed. It's possible there was so much NAPL exiting the seep that the filter quickly absorbed all the NAPL it could and the rest simply flowed through it or around it. This begs the question of replacement.

The reactive core mat placed over the IRM seep only needed to last 2 years, per the plan when it was installed in 2016. The permeable reactive barrier the MIRP will place along the west and south shorelines in 2028 will be under riprap. It's a filter that is never meant to be replaced. If it's confusing, it's because the MIRP's plan for the permeable reactive barrier is something of a mixed message. According to PG&E, the permeable reactive barrier “*is included in the remedial action as a containment remedy as an additional measure of protection to address the future potential for groundwater to discharge to surface water.*”²⁰ The phrase “as an additional measure” requires unpacking. This language refers to the MIRP's objectives, the Water Board's requirements, and a 2018 consent decree.²¹ PG&E is saying that no one is making them install the permeable reactive barrier but they want to do it anyway. Why? The quote continues “to address the future potential for groundwater to discharge to surface water” but that only states the obvious. Why is PG&E taking this extra measure, a filter that cannot be replaced required by no one, to protect Bay water from groundwater? Because PG&E is worried about it. If PG&E is worried about it, BCDC should at least be a little concerned. Once again, this involves the difference between seen and unseen. Low permeable backfill, possible sheeting, and permeable reactive barriers are all measures that have some chance of keeping NAPL out of Bay waters and have zero chance of keeping groundwater out. Seen versus unseen is essentially a matter of degree, concentration, dilution. Blobs and sheens are an embarrassment but groundwater near NAPL, especially groundwater in discontinuous NAPL, always tests above acceptable limits. Surface water never tests above limits because when the chemicals enter surface

water they are instantly diluted. Why should BCDC care? Approving chemical storage, which is unavoidable, means accepting a role in the natural cycle. It is the fate of Gashouse Cove that it will always be receiving small amounts of contaminated groundwater, it will dilute the chemicals and move them to the Bay which will then send them out to the Pacific. What about replacing the filters? PG&E hopes blobs and sheens will never be seen again, or it will be such a long time it will be viewed as a separate problem and the company will deal with it then. A permeable reactive barrier along the west and south shorelines is a cost-effective measure for PG&E if it does nothing more than buy time.

The important aspect of MIRP's plan for a permeable reactive barrier, however, has not been discussed. It is that this 'additional measure of protection' is focused solely on the shoreline and ignores the bottom. There are large quantities on chemicals distributed heterogeneously under the sediment.²² Because Gashouse Cove was dredged when the boat harbor was built, the depth of these chemicals is 8' MLLW and below:

Gashouse Cove's depth at inception of the boat harbor

Reference	Mark	CCSF	USC&G
19700409 ²³	CCSF Datum	100.0'	+11.7'
19720623 ²⁴	Max High Water	95.3'	+7.0
19700409	MLLW	88.3'	0.0'
19720623	Min Low Water	86.3'	-2.0
19620115 ²⁵	Toe of Slope	80.0'	

- Depth at inception: MLLW minus Toe = 8.3' rounded to "8' MLLW" for Report
- Typical tide swing near Fort Mason 4' to 6'
- King tide swing near Fort Mason ~9'

Figure 26 illustrates the potential for chemical seeps for the stepped bottom and the flat bottom options. In areas not dredged, the 8' MLLW ceiling for the chemicals means there are several feet of uncontaminated sediment above the chemicals. The engineered cap for the dredged areas is still being designed. It may consist of a chemical isolation layer similar to the permeable reactive barrier or a low permeable barrier similar to the backfill in the IRM. Either choice presents the same difficulties as above. The bottom line is that, as with the shoreline, there are barriers that have a chance of constraining NAPL but there is nothing that will inhibit the interchange of porewater under the sediment with surface water in Gashouse Cove.

Chemical Storage, Unproven Remedy, and Risk

A discussion about MGP chemicals cannot end without mentioning the Water Board's decision to accept both remedies shown in figure 22. The Water Board has extensive

experience with engineered caps and no experience with using the contested block for protection.²⁶ At the same time, the Water Board has full confidence in its decision. The decision is based on sampling that has shown little or no contamination in shallow porewater where it might harm benthic organisms and no contamination in surface water where it might harm humans. Thus, the Water Board has – reasonably, given its perspective and its authority – determined that the MIRP is protective of health and the environment. It has stated that it will defend its decision until data proves otherwise.²⁷

To be clear, there is no data to prove otherwise. The MIRP may indeed be adequate to protect health and the environment. But there is risk. There are chemicals everywhere in the industrial world, most are unknown. Some have undoubtedly been in bays beneath several feet of clean sediment and done no harm to anyone or anything for centuries. But South is not remote and it's not a fenced-off industrial site. It's part of the most well-known and visited shoreline on earth. The plan is to use South for water contact sports and shoreline entertainment. The Water Board is making a defensible decision based on science and data but it is not giving enough weight to the location and use scenario. Gashouse Cove is known to be surrounded by chemicals. Its borders and everything in it is manmade except for the bottom. The more appropriate decision in this situation is to select the proven and robust protection method for South as is being done for North.

BCDC cannot follow the Water Board's example. The Water Board is unconcerned with risk. If the unproven remedy fails, or any other part of the MIRP fails, the Water Board says it will simply make a different decision.²⁸ BCDC does not have that luxury. If BCDC allows the Contested Block to be used as a protection layer for chemicals, that decision can never be reversed. Should something cause the Kayak/SUP area fail, other uses for South may be tried but BCDC cannot take back what it has given away.²⁹

The Laguna Street CSO

Odors, Steam, and Sometimes a Torrent

Sewer water combined with stormwater periodically discharges from the Laguna Street outfall into Gashouse Cove.

“Significant rain always causes discharge from the outfall. Additionally, the outfall produces horrific odors and steam when the weather warms up. So, there is never a time when it is not producing something.”

Chrissy Kaplan, Owner/Operator of the Fuel Dock
in Gashouse Cove for the last 50+ years.

The discharge varies from a trickle to a torrent [[Video 3](#)].³⁰ Both frequency and volume are expected to rise due to climate change. Stormwater entering Gashouse Cove could be considered beneficial. However, when combined with sewer water the net effect is negative. Fresh stormwater provides brief dilution but pathogen and biochemical oxygen demand loading from the sewage constituent dominates in every scenario. Figure 27 illustrates a typical discharge discharging from the pipe in the southeast corner. As described in connection with the multi-box simulation, pollution introduced in one location distributes throughout the system and persists until tidal flushing clears it from every corner. Contamination introduced from this source is an additional burden on water quality.

Pierce Street Closure

The closure of the Pierce Street outfall in 2021 is directly relevant. In anticipation of the closure, SFPUC did hydraulic modeling and acknowledged *“the number of CSD events increases at the Laguna outfall.”*³¹ The receiving water quality analysis noted that *“Gashouse Cove Marina”* was one of the areas impacted and yet the modeling was not completed for the storm event where Laguna discharges as a direct result of Pierce’s closure.³² Pierce typically discharged 7.1 MG a year in the past. That volume must now be redistributed among the remaining outfalls. Baker absorbs the lions share but Laguna carries a discharge burden it previously did not have. Since it closed in 2021, residents have reported sewage flooding in the Marina and petitioned SFPUC to reopen Pierce. Lawsuits claiming the Pierce Street closure exacerbated flooding and caused sewage backups into homes are still open. Politically, it appears the City would rather compensate homeowners each time there’s a storm than repair the sewer system. There is no engineering solution being contemplated at this writing. Recently, the Water Board

pressured and the City finally agreed to spend \$600M on new sewer capacity, but none of it is targeted to Pierce Street or the Marina.

Risk Factors

San Francisco's CSO system is a notorious polluter. The City has been the subject of Federal and State lawsuits that specifically cite areas popular for kayaking as at risk from untreated sewage discharge.³³ SFPUC posts "No Swimming" advisories at affected recreational sites following CSO events. South's designation as a Kayak/SUP area heightens the public health significance. Dedicating a facility with an active sewer outfall in the corner to water-contact recreation is risky. At best it will face recurring closures and reputational harm that directly undermines the use rationale.

At worst, torrents of the kind seen in Video 3 will wash away enough of the accrued silt to expose the toxic chemicals that lie beneath South. Sewer experts predict a cut channel similar to the prop wash channel as a minimum. The current work being done on the Laguna Street outfall, adding some rip-rap outside the pipe, is wholly inadequate to prevent any of this. If the City is unable to engineer a fix for the sewer system, then a stilling basin is the only thing that might prevent this from happening.

Why should this matter to BCDC? Because it stands to lose too. BCDC will certainly authorize the MIRP and if the applicants fail then BCDC will lose a critical Bay resource.

Discussion and Recommendation

Gashouse Cove begins with a structural disadvantage. It is a partially enclosed, manmade inlet with no natural freshwater source, no through-flow, and no mechanism for water renewal other than tidal exchange through a single opening. The floating dock array covering North suppresses wind mixing and surface circulation. Bottom sediments contain toxic chemicals from decades of manufactured gas plant operations — chemicals that continuously seep in minute amounts into the water column and must travel to sea to be fully remediated. A combined sewer outfall regularly discharges raw sewage and stormwater into a corner, with frequency and volume expected to increase as climate change intensifies storm events. These conditions are not hypothetical. They will not be resolved by the MIRP's remediation component. They are the permanent operating environment of Gashouse Cove.

Any decision about the cove's configuration must be evaluated against this reality. Poor circulation in this context means prolonged pathogen exposure after each CSO event, reduced dilution and transport of chemicals, oxygen depletion in bottom waters, and

progressive worsening as South shoals over decades because there is no practical way to maintain a depth floor. The question is not whether Gashouse Cove faces water quality challenges. The question is whether those challenges are better or worse with the MIRP.

The answer is ‘worse.’ The technical analysis described earlier proved that the MIRP is detrimental to water quality. The negatives from the breakwater extension and the trough outweigh the positive from reducing the volume. The finding is important given the contamination sources present in Gashouse Cove. Spills and debris from boats. Harmful chemicals that enter, unseen and undetected, from bottom sediments require mixing to dilute and transport them to the Bay — mixing that does not occur in North’s trough. CSO discharges from the Laguna Street outfall enter as a surface plume in a basin so shallow that the entire water column is contaminated almost immediately. Long-term siltation will progressively shoal South further and degrade already limited circulation.

The residency time argument in favor of the MIRP — that a smaller basin volume flushes faster — is technically accurate as stated but misleading in context.

What does that mean to BCDC?

- The Bay Plan’s Recreation Policy #3 requires BCDC to find that water quality and circulation “*will be adequately protected and, if possible, improved*” before approving a marina.³⁴ The MIRP fails that test.
- The Water Surface Area and Volume Policy #1 requires that water volume be kept “*as large as possible*” to maximize circulation and tidal action, and that any reduction be allowed only when there is “*no reasonable alternative*.”³⁵ The MIRP clearly does not do that, it does the opposite.
- The Water Quality Policy requires that pollutant effects be reduced by “*maintaining and increasing the volume and circulation of water flowing in and out with the tides*.”³⁶ For volume, this is the one water quality requirement that the MIRP adheres to. For circulation, not so.

The application for permit contains a section where the applicants self-report the MIRP’s adherence to BCDC’s laws and policies. It is “*Table 5. Project Compliance with BCDC Laws and Policies*”. The table, which begins on pdf pg 59 or document pg 2-35, can be found at this [\[Link\]](#). The applicants answer every question with “consistent” and some explanatory text. The entries are disputed here with respect to the above bullets and all the entries about fill. It is tempting to alleged them to be false statements but, charitably, it may be perspective, overzealousness, or a peculiar set of blinders. BCDC will be the arbiter.

More robust modeling and simulation would allow these conclusions to be expressed with greater precision and is recommended. In its absence, the weight of physical and engineering evidence supports the conclusion: the MIRP is detrimental to water quality. BCDC's policies oblige it to reject the application.

Dan Clarke
20260729

Figures

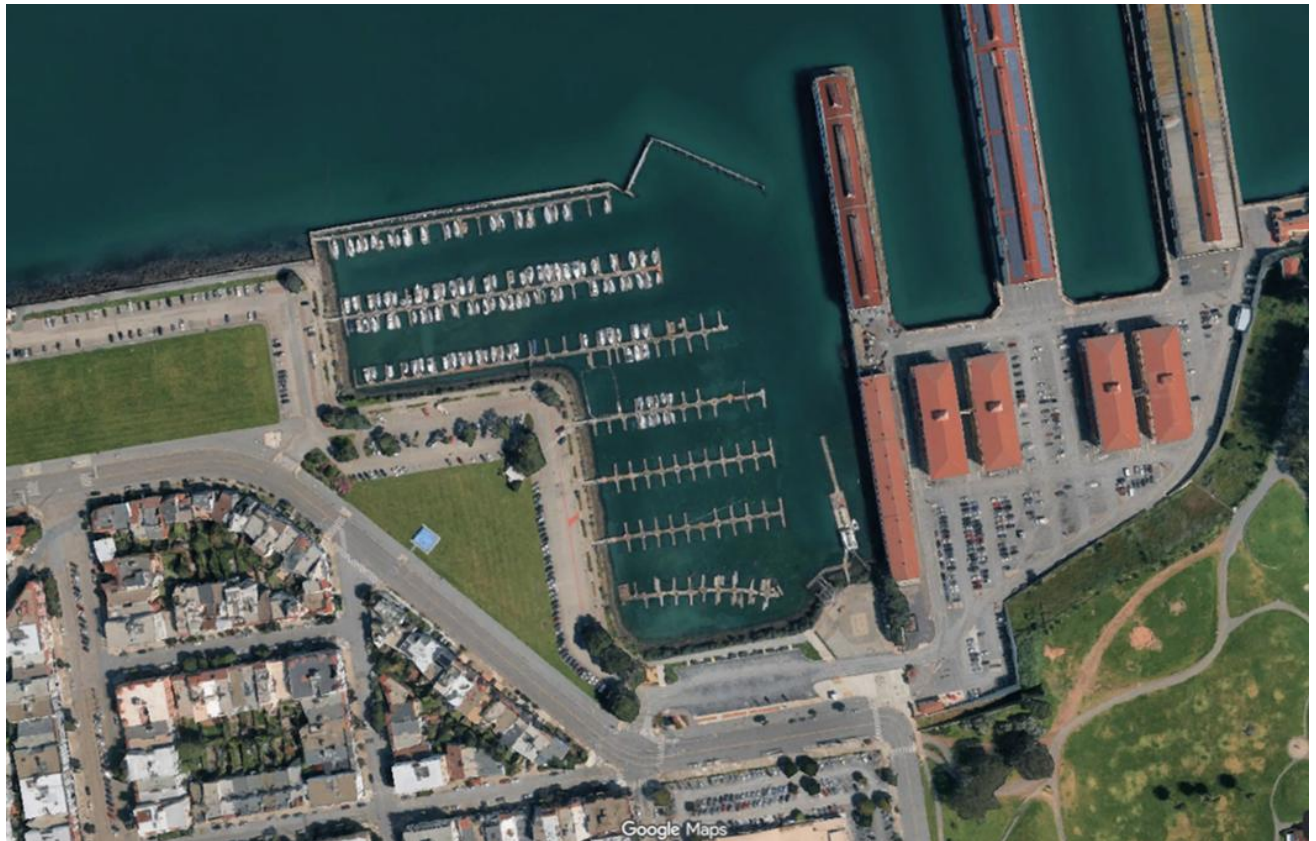


Figure 1 Gashouse Cove

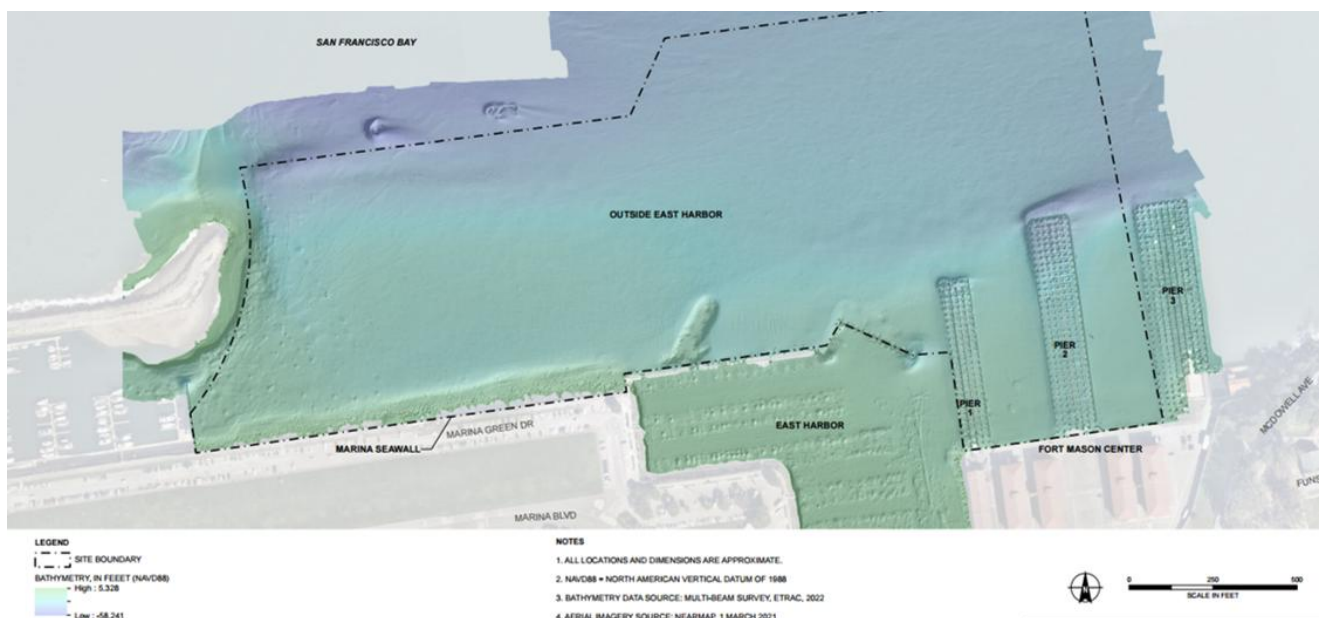


Figure 2 Bathymetry of Gashouse Cove and SF Bay³⁷

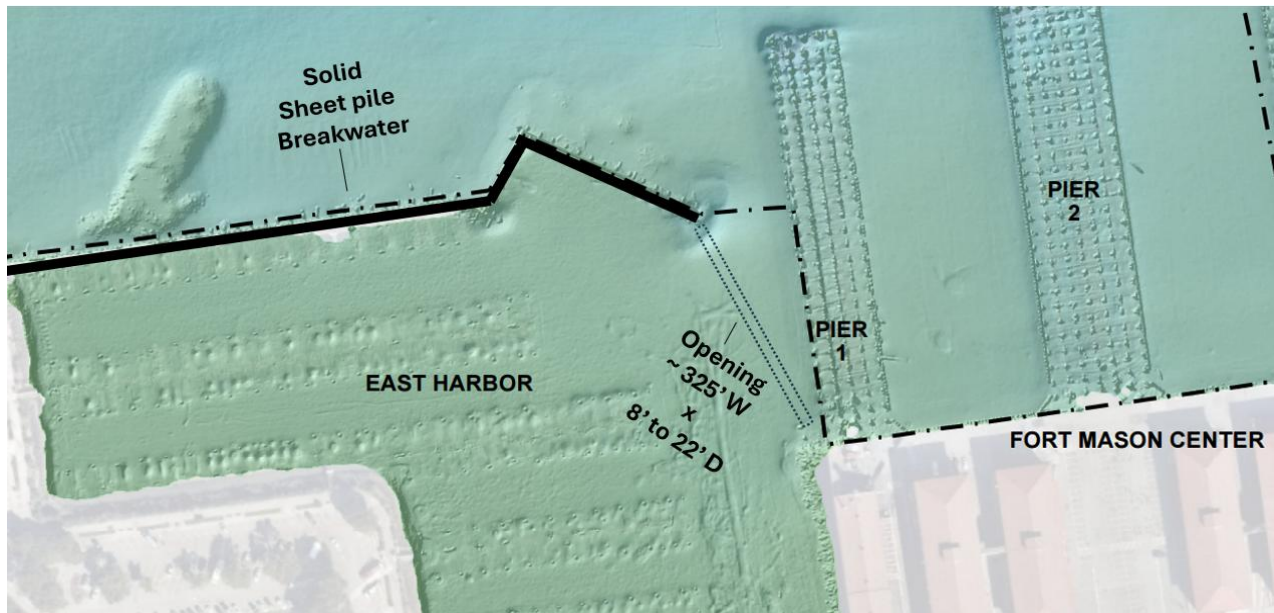


Figure 3 Gashouse Cove opening before the MIRP



Figure 4 MIRP

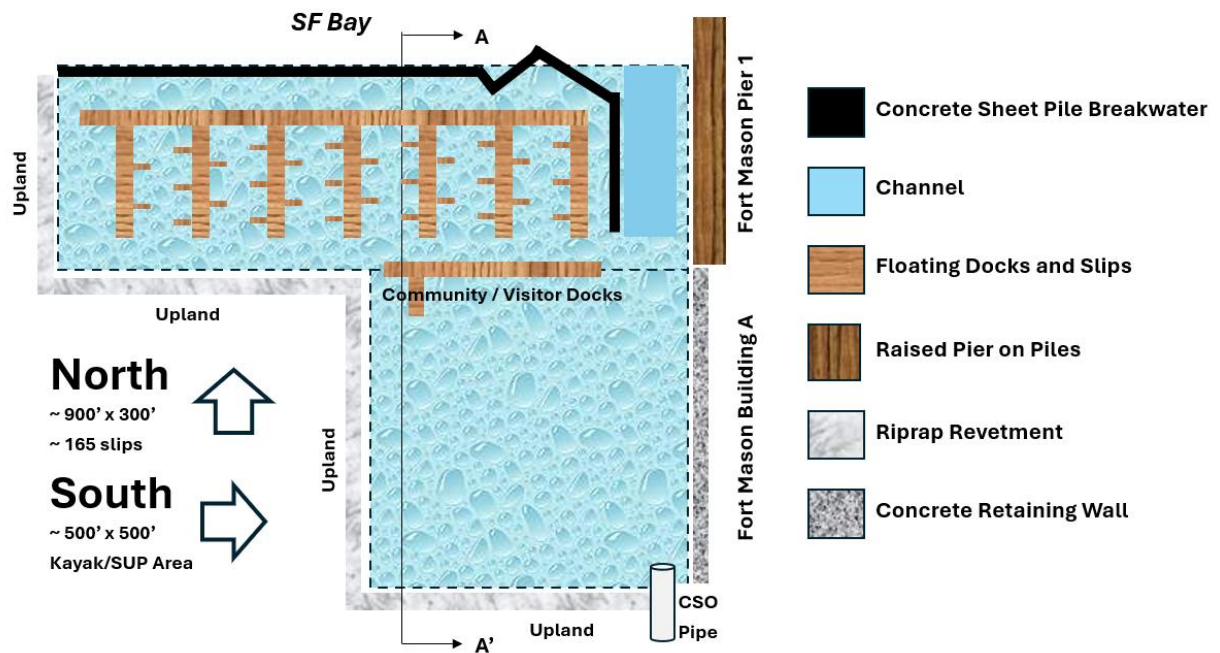


Figure 5 Elements of the MIRP simplified for modeling

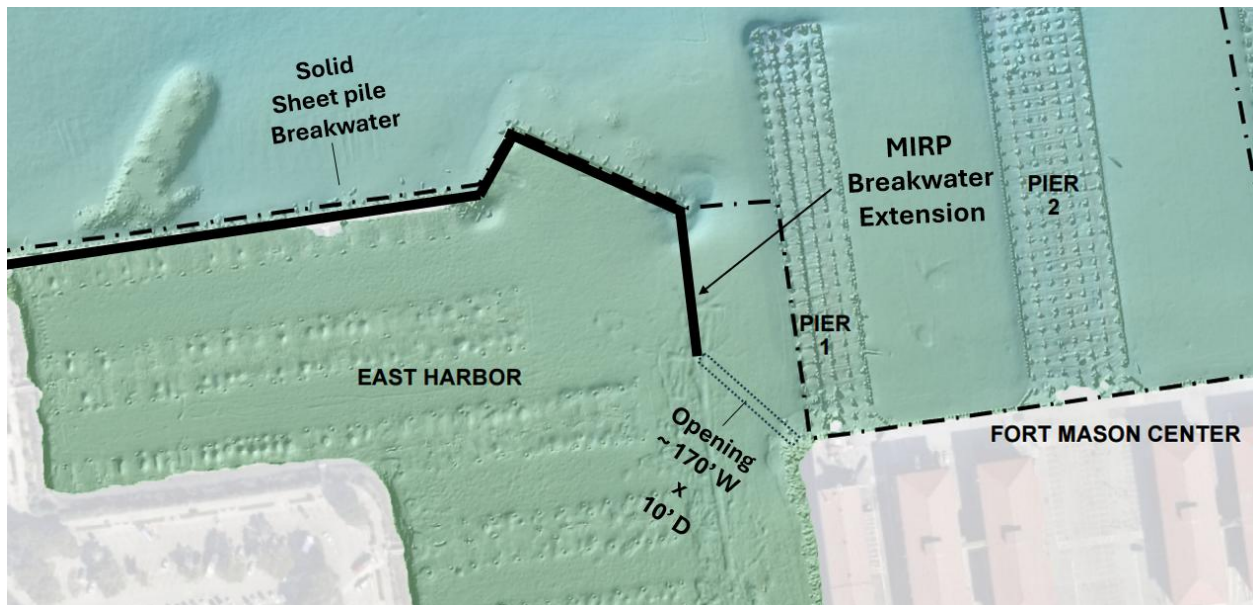


Figure 6 Gashouse Cove opening after the MIRP

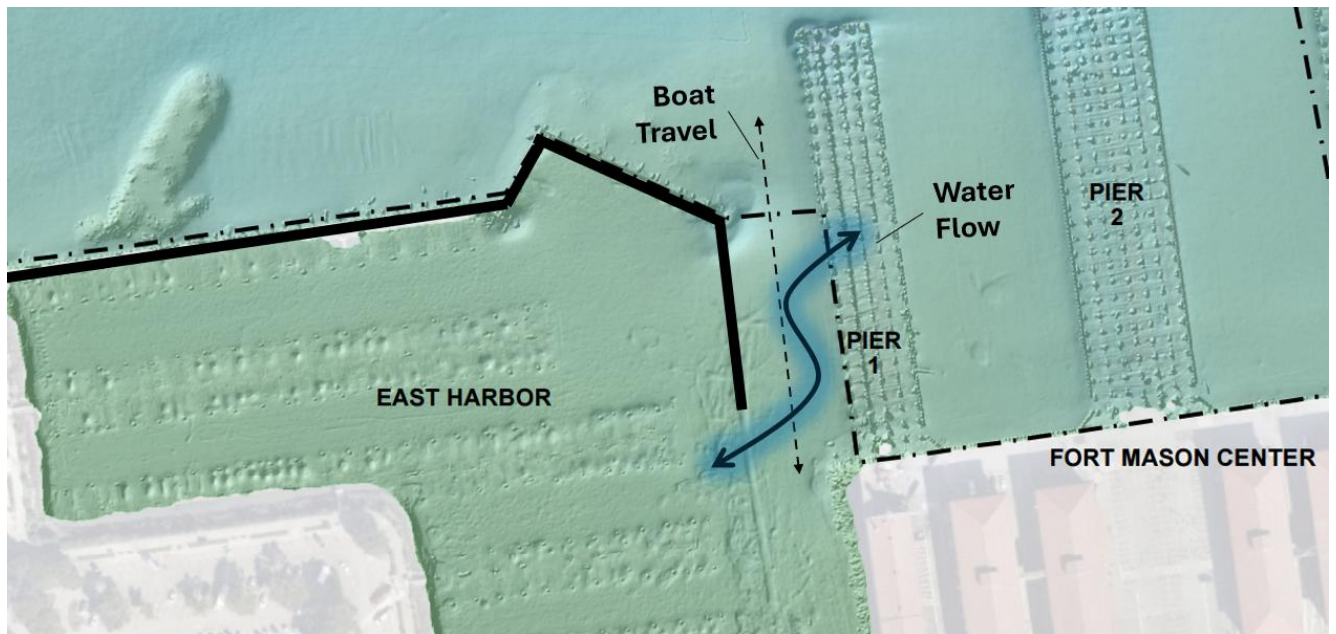


Figure 7 Illustration of Tidal ebb and flow after the MIRP. Note that Pier 1 is on piles.

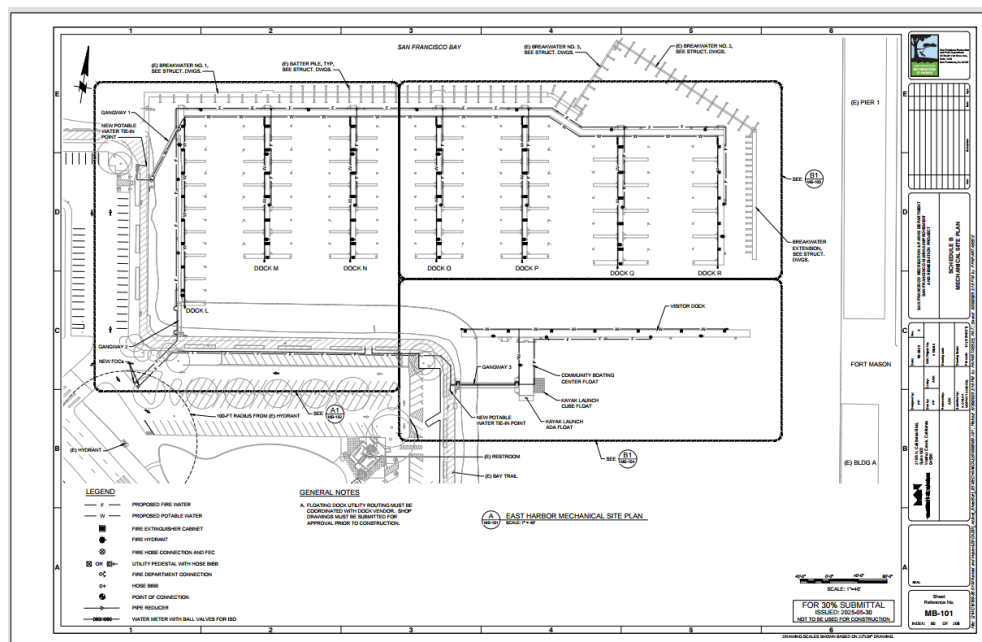


Figure 8 MIRP Engineering Specification for Surface Features

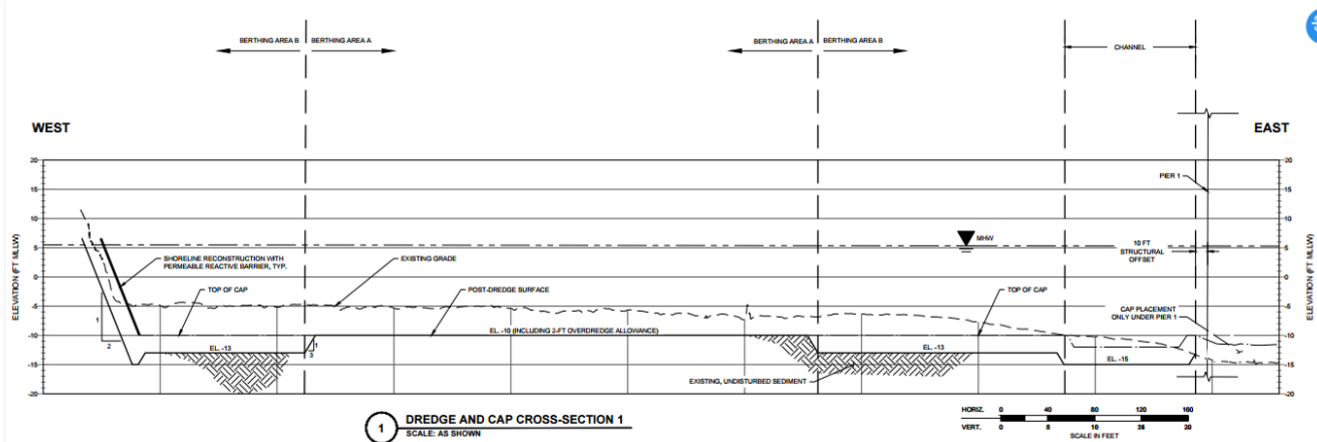


Figure 9 Cross section of North's berthing and channel area³⁸

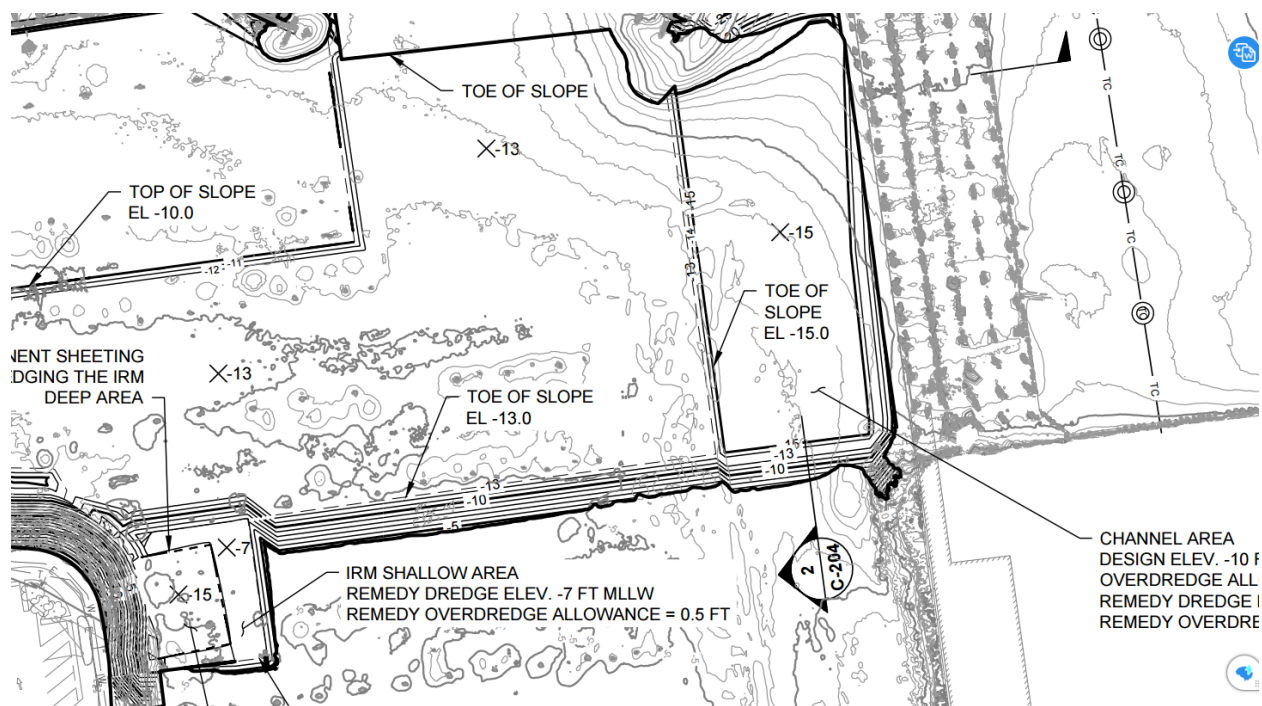


Figure 10 Bottom topology detail

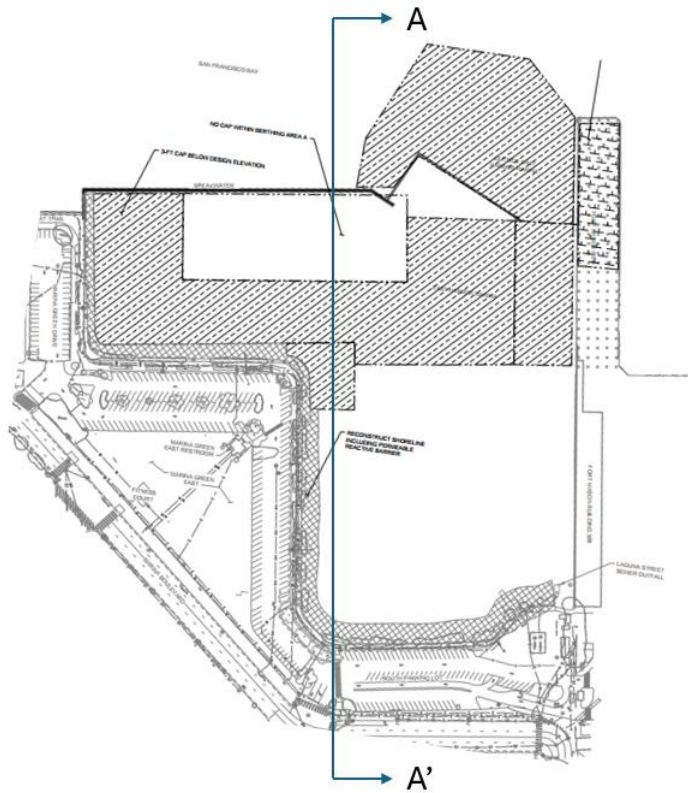


Figure 11 MIRP Crosshatch Areas indicate areas to be dredged and capped

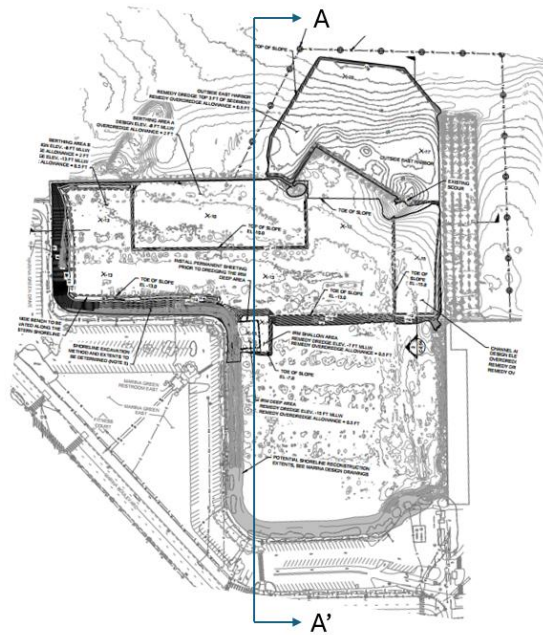


Figure 12 MIRP Detail of dredge depths and bottom topology

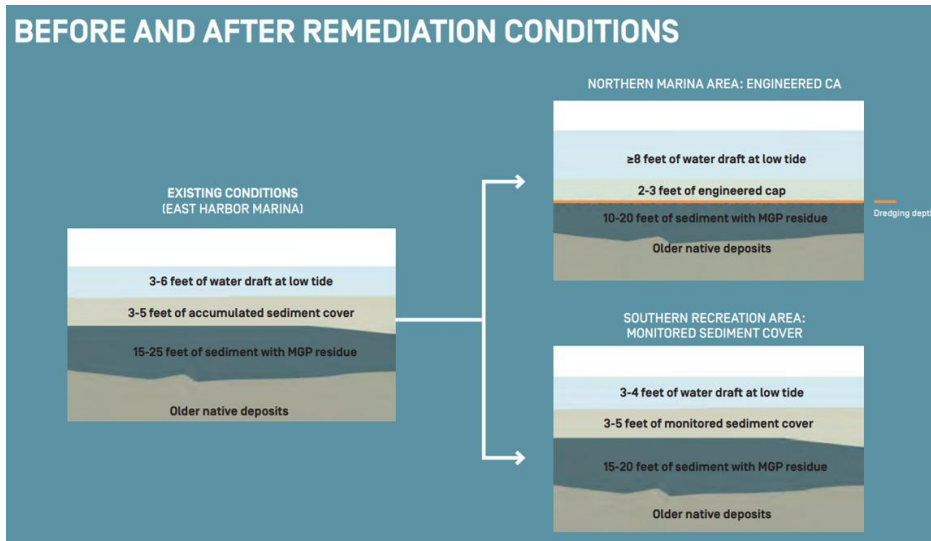


Figure 13 MIRP Description of Layers in Capped and non-Capped Areas

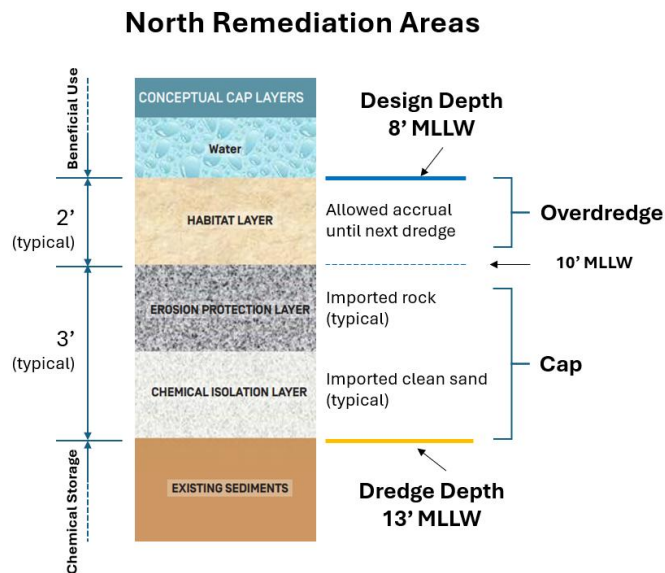


Figure 14 MIRP Illustration of Dredge Depth, Cap Layers, and Overdredge in North

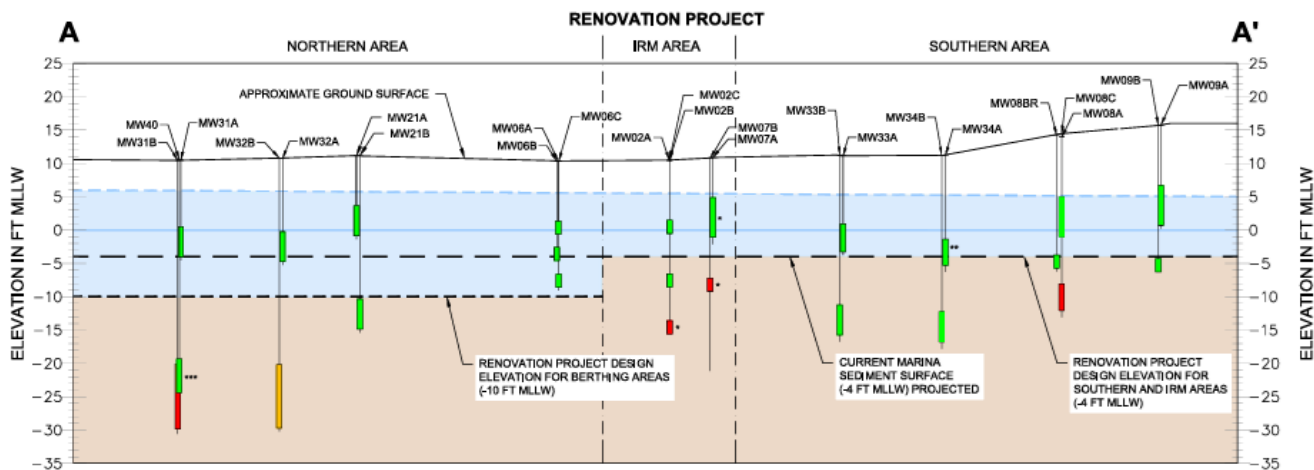


Figure 15 MIRP Shoreline Trace Illustrating Stepped Bottom Contour at High Tide

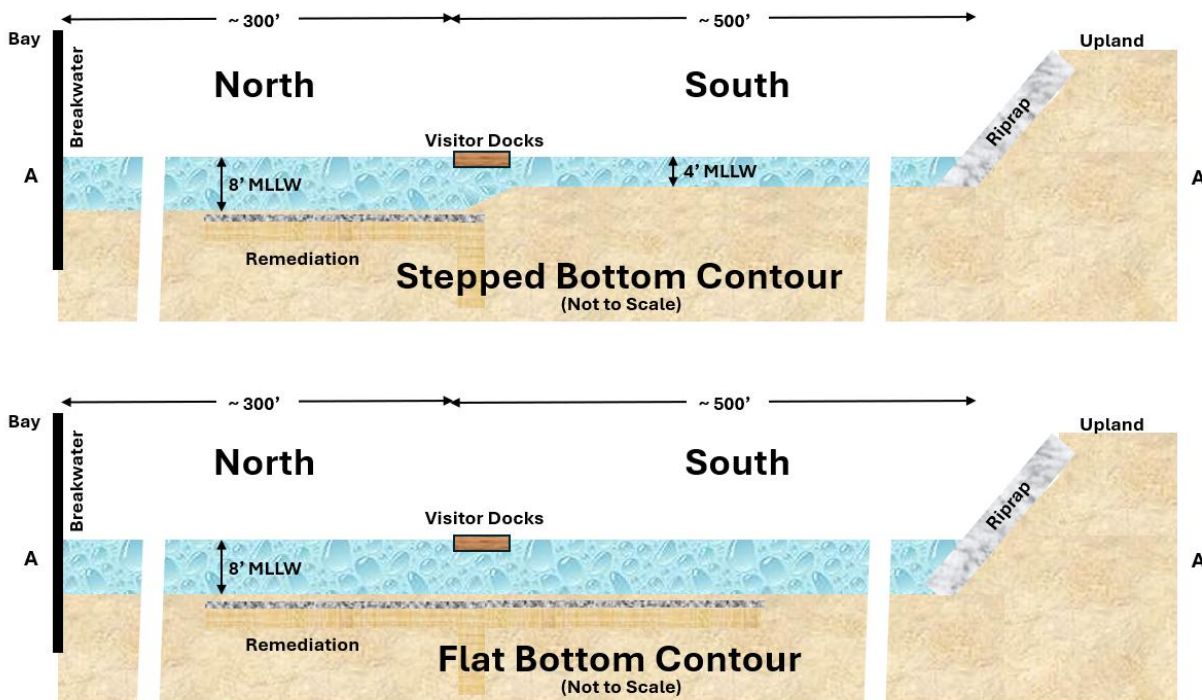


Figure 16 Profile Illustrating Different Bottom Contours at low tide without and with the Condition



Figure 17 Steps in the Bottom Contours of Gashouse Cove from MIR

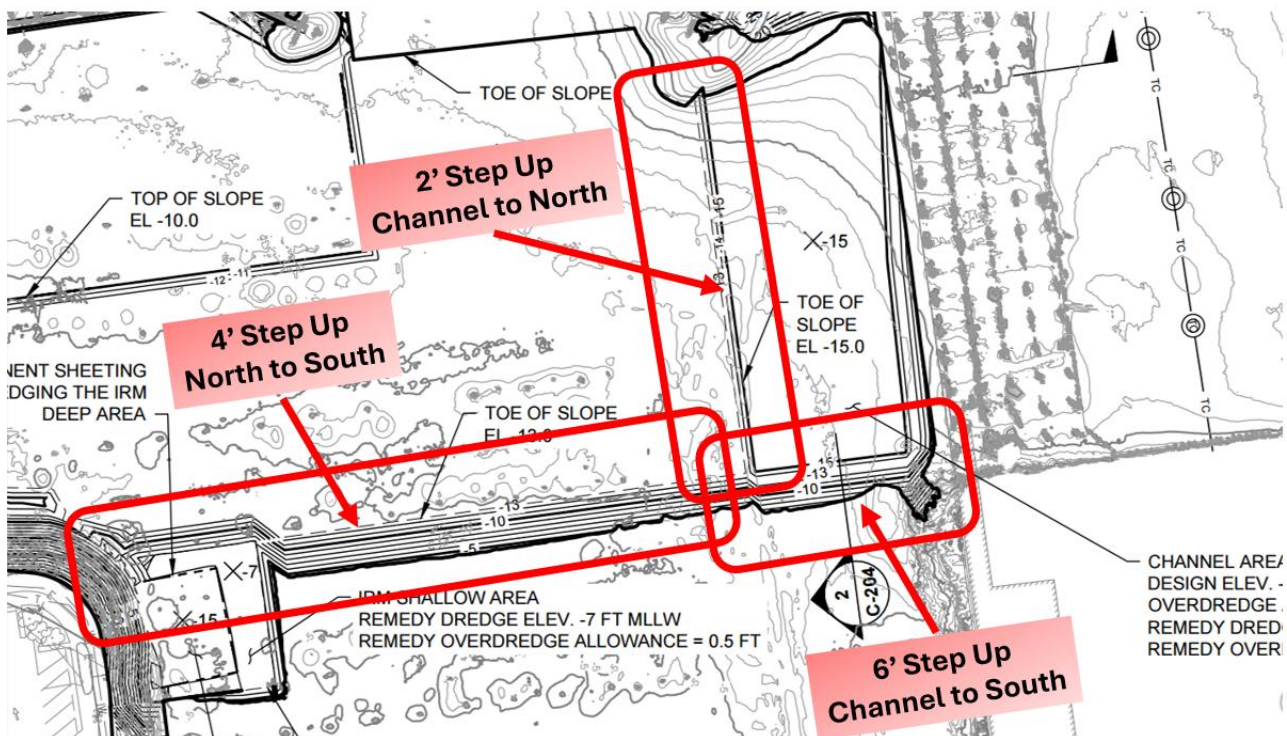


Figure 18 MIRP Dredging contours illustrating steps

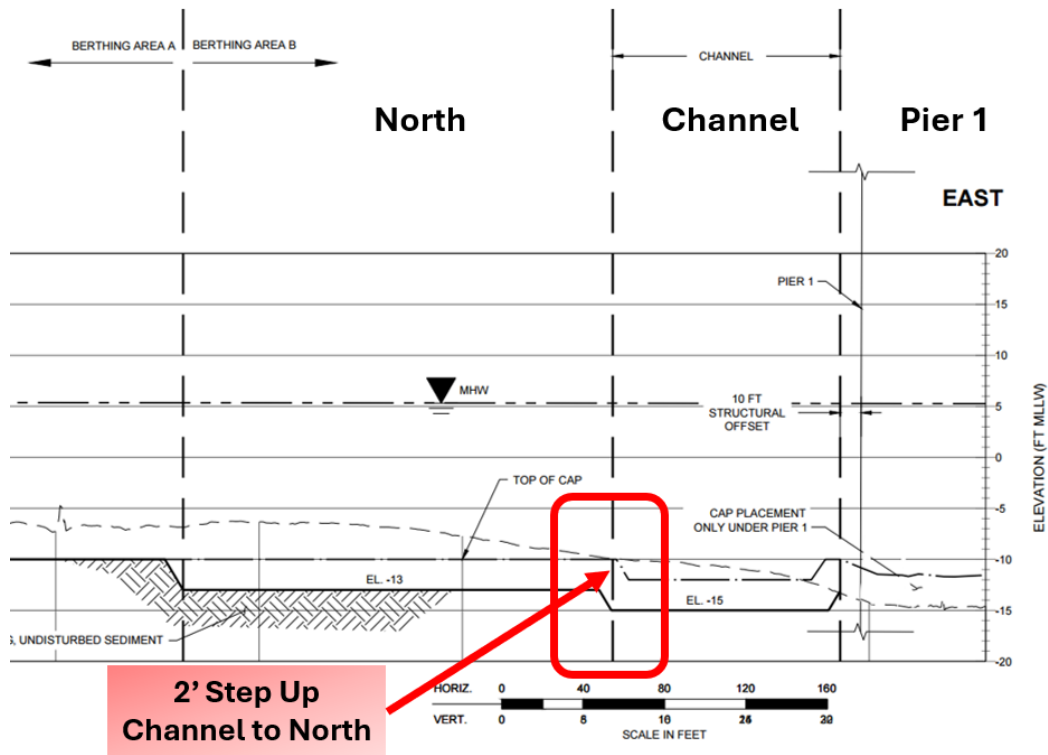


Figure 19 MIRP Profile depicting 2' Step from Channel to North

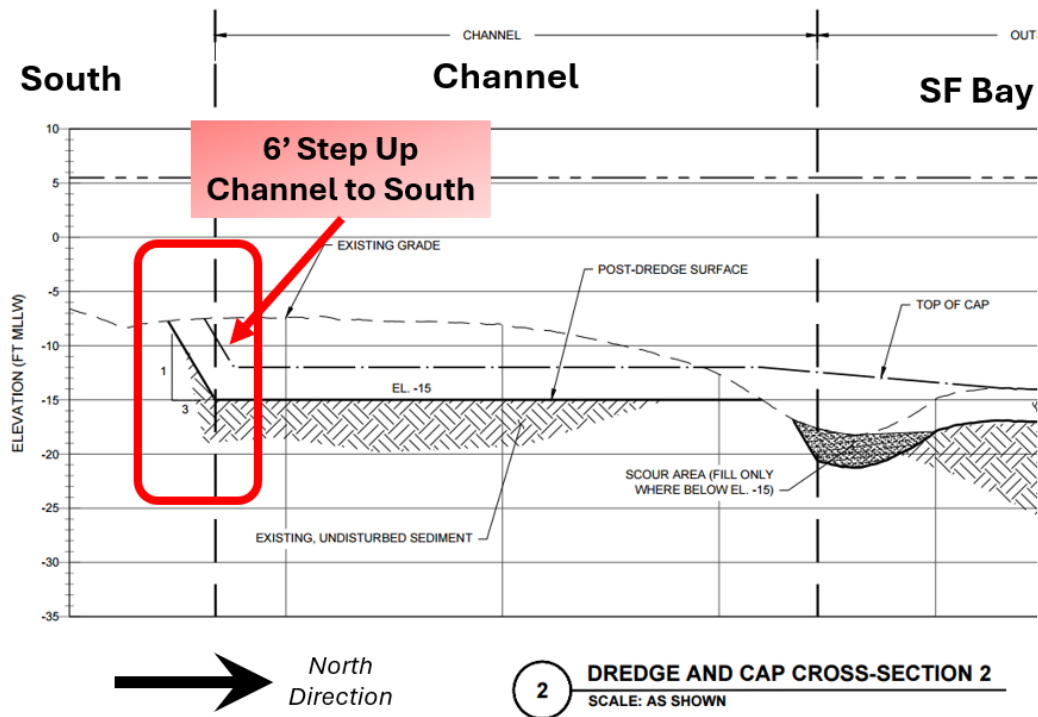


Figure 20 MIRP Profile depicting 6' Step from Channel to South

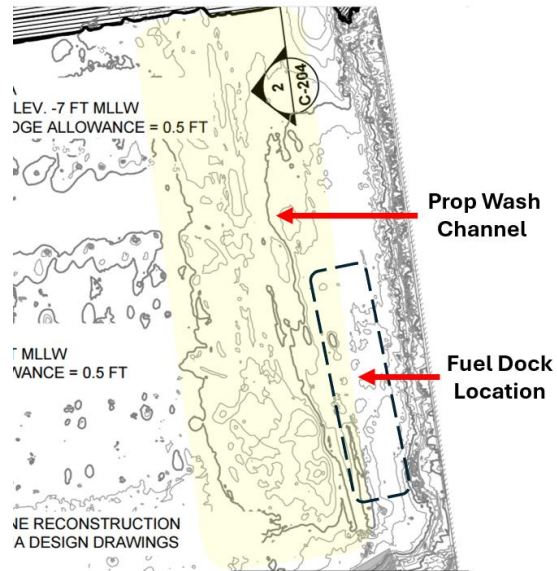


Figure 21 Current Bottom Contours showing Prop Wash Channel

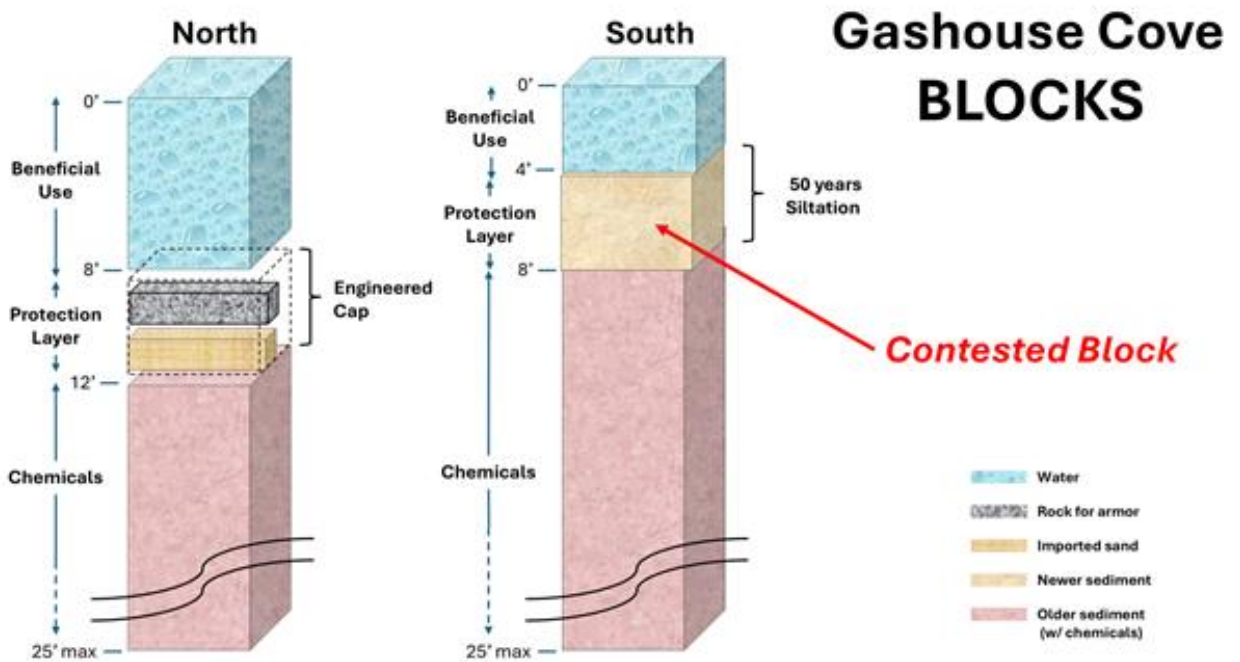


Figure 22 Repeat of an unnumbered Figure from the Report



Figure 23 Skirted Boom IRM



Figure 24 Permeable Reactive Barrier on West and South borders

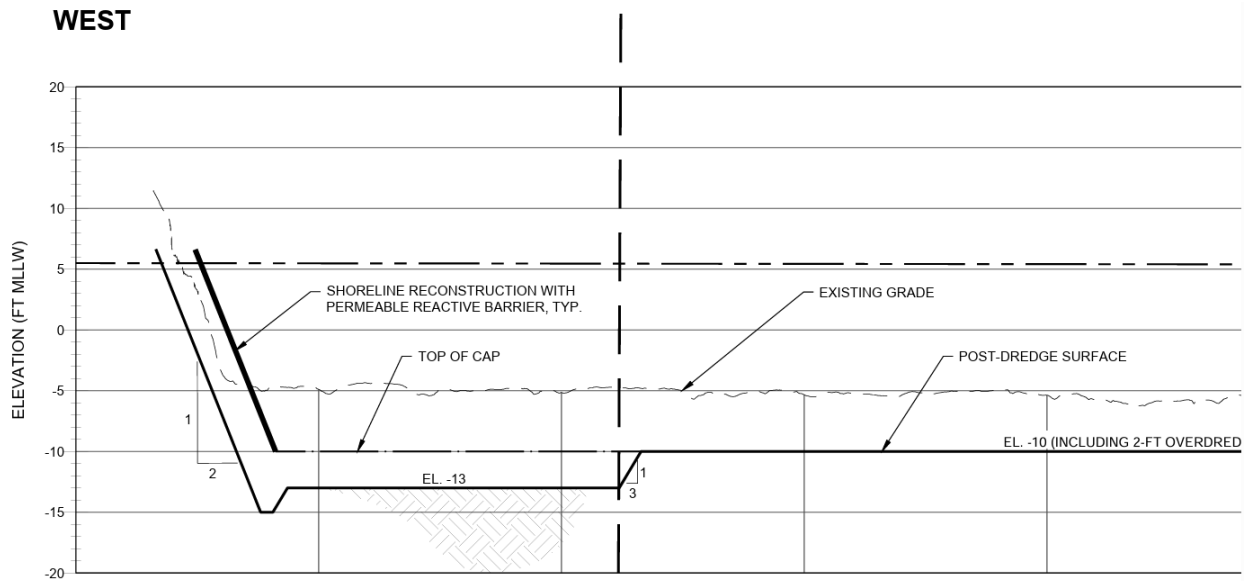


Figure 25 Permeable Reactive Barrier profile on West border

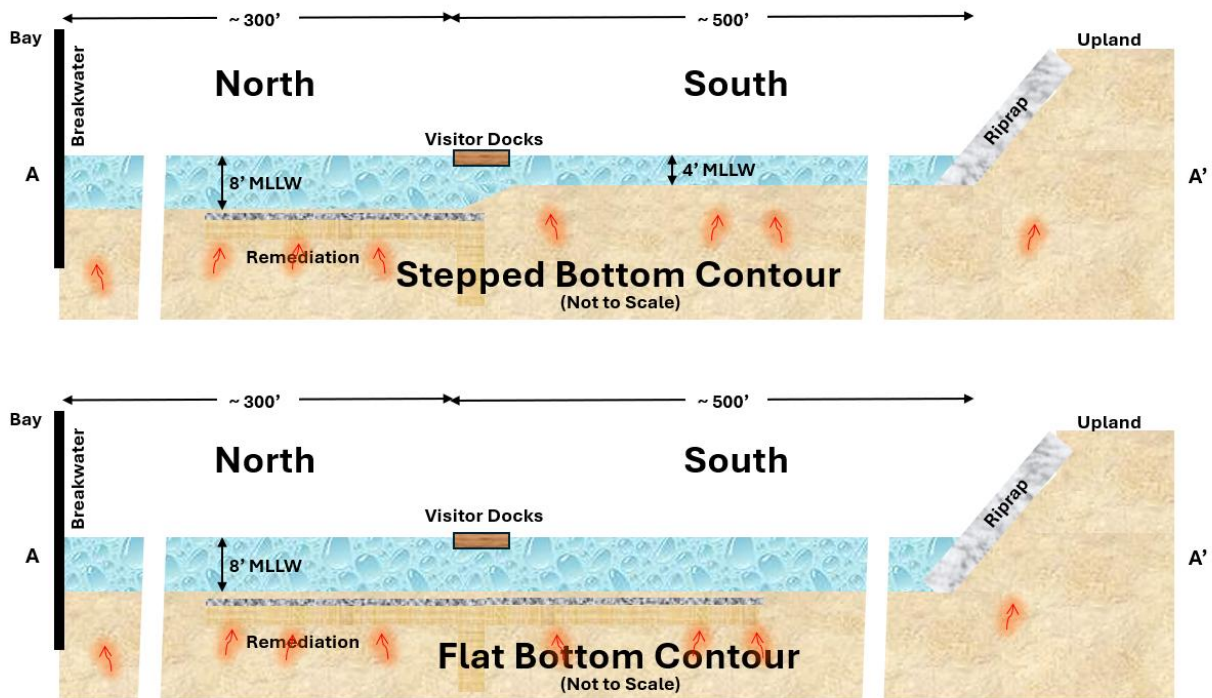


Figure 26 Illustration of chemicals below sediment

Laguna Street Outfall CSD - Hours of Impact

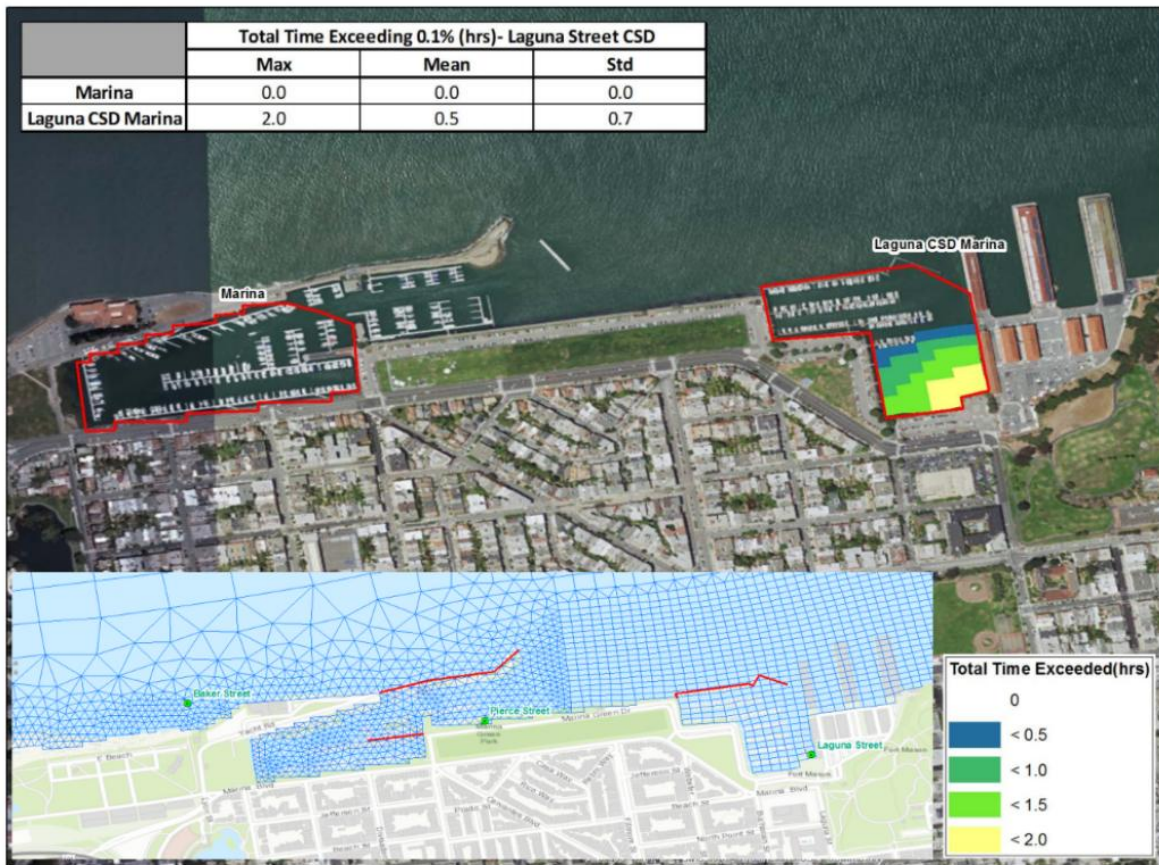


Figure 27 Modeling the effect of discharges from the Laguna Street CSO

Attachment: Comparative Performance Analysis

ATTACHMENT

Comparative Performance Analysis

Two Basin Alternatives: ORIG vs. MIRP

July 2026

1. Introduction

This analysis compares the performance of two basin configurations, ORIG and MIRP, which differ in basin geometry. The objective is to determine, on an engineering basis, how efficiently a contaminant contained in each basin is flushed to open water. Two complementary approaches are used: a tidal prism analysis and a multi-box sub-zone simulation.

The configurations of ORIG and MIRP are defined in Section 2. Section 3 describes the tidal data used for both alternatives. Section 4 presents a tidal prism analysis using simple geometric relationships -- volume exchanged per tidal cycle versus basin volume -- which requires no simulation and treats each alternative as a single well-mixed basin. Sections 5 and 6 present and validate a multi-box sub-zone simulation that resolves the basin's internal structure. Section 7 presents four point-source spill scenarios that represent plausible real-world spill locations across the basin's structurally distinct regions. Section 8 provides a short set of conclusions. Sections 9 and 10 contain tables and figures.

2. Site Geometry

The project site is Gashouse Cove located in San Francisco's Marina district along the City's northern shoreline. Gashouse Cove was designed and built as a small craft harbor in the late 1960s and operated as such for about 50 years. Figure A1 shows the idealized geometry of the original design, ORIG. It is used here for modeling and simulation. The City is currently proposing a Marina Improvement and Remediation Project for Gashouse Cove. Figure A2 shows the idealized geometry of the City's proposal, MIRP, used here for the same purpose.

For the simulation, Gashouse Cove is divided into five named regions: C, for channel, an antechamber with direct frontage on the Bay; NEN and NES, the north and south portions of the basin's northeast section; NW, the northwest section; and S, the southern portion of the basin. The five regions are shown for ORIG and MIRP in Figures A3 and A4, respectively. These same five regions are carried forward as the basis for the circulation model described in Section 5.1.

MIRP differs from ORIG in two independent physical respects.

- A new breakwater extension of approximately 180 feet encloses the NEN region on its east side. Its purpose is to better protect vessels from persistent NE swells. Its effect on water quality is negative because it creates enclosed corners and inhibits circulation pathways that remain open under ORIG.
- A stepped bottom contour utilizing built-up siltation reduces basin depth in the S region under MIRP, relative to ORIG. Its effect on water quality is positive because it reduces the total volume of water to be cleaned and negative because it creates a difficult-to-clean trough in the northern sections.

3. Tide Monitoring Station and Tidal Data

Tidal boundary conditions used throughout this report -- for both the tidal prism analysis and the multi-box simulation -- are referenced to NOAA Station 9414290 which is located on a pier about 2,000 feet east of the Golden Gate Bridge. This station has recorded continuous tide data since 1854 making it the oldest continually operating tide gauge in the Western Hemisphere and NOAA's primary long-term tidal reference for San Francisco Bay; it is the standard datum reference against which subsidiary Bay stations are set.

Station datums for the current National Tidal Datum Epoch (1983-2001) give Mean Higher High Water at 1.780 m and Mean Lower Low Water at 0.000 m (station datum), a mean range of 5.84 ft. The 12.4-hour tidal period reflects the semidiurnal (twice-daily) tide characteristic of San Francisco Bay. The simulation's timestep-by-timestep tidal forcing is derived from NOAA's published tide predictions for this station. Table 1 contains only the resulting summary range and period, not the full predicted water-level record, which is maintained at the source and not reproduced in this report.

4. Tidal Prism Analysis

A simple tidal-prism calculation is presented here as a baseline.

The tidal prism is the volume of water exchanged between mean low and mean high water. The ratio of tidal prism to basin volume is a standard first-order approximation of flushing

efficiency. It relies on the assumption that the basin mixes completely each tidal cycle. That is, the calculation uses only the basin's total volume -- it has no knowledge of internal connectivity, dead zones, or circulation.

Because the footprint (535,000 sf) is identical for both ORIG and MIRP, the tidal prism is identical for the two alternatives: 3,124,400 cuft. On the other hand, the basin's volume is not identical. MIRP's stepped bottom contour removes (500' x 500' x 4') 1M cuft. The results:

	ORIG	MIRP
Tidal prism (cuft)	3,124,400	3,124,400
Basin volume @ MLLW (cuft)	4,340,000	3,340,000
Prism / volume ratio	72.0%	93.5%

The larger the prism-to-volume ratio the more efficient the alternative is at flushing contaminants out of the basin. This reflects the Faustian bargain that you can always make a basin flush more efficiently by filling in the basin.

Nonetheless, by a tidal-prism analysis alone – total volume only, no internal geometry or circulation considered -- MIRP is the better-flushing alternative.

5. Simulation Engine

5.1 Simulation Geometry

For simulation purposes, each of the five regions introduced in Section 2 becomes a “stack” of boxes, divided vertically into layers of uniform thickness. Figure A5 is a schematic representation of the stacks, layers, and boxes. Layer 1 is the surface layer and is the only layer whose volume changes with the tide; Layers 2 and deeper are treated as fixed-volume, allowing water to pass through without the layer's volume changing.

C has five layers; NEN, NES, and NW have four layers in both alternatives. S has four layers under ORIG and two layers under MIRP. The stepped bottom contour described in Section 2 removes the deepest two layers of the S stack, so S3 and S4 do not exist in MIRP. Table 2 has each stack's plan dimensions, footprint area, and layer count.

The two independent physical differences between MIRP and ORIG described in Section 2 are represented in the model as follows:

- The stepped bottom contour removes S3 and S4 entirely under MIRP. This removes roughly 23% of total system volume at mean lower low water (MLLW), relative to ORIG, a significant decrease.
- The breakwater extension enclosing NEN's east side removes NEN's direct horizontal connection to C at all four of NEN's layers (360 sf opening each under ORIG). Under MIRP, NEN can only reach the Bay through NES or NW; it cannot reach the Bay directly through C.

Both changes are reflected in the horizontal connection table (Table 3).

5.2 Development and Purpose

The simulation engine (“sim_5”), a multi-box sub-zone tool for evaluating tidal flushing, was developed specifically for the ORIG vs. MIRP comparison. Sim_5 is a mathematical model computer simulation that tracks how long it takes for a basin to replace dirty water with clean water through tidal action. It divides a large basin into several smaller, interconnected “boxes” to simulate water movement and pollutant dilution. For this analysis, sim_5 k a 21-box model for ORIG and a 19-box model for MIRP.

When sim_5 runs, every box (all active layers in all stacks for each alternative) and every connection between boxes (horizontal and vertical) is solved as a single simultaneous potential-flow network each timestep. Layer-1 boxes are assigned a required net volume change each step, driven by the tide data from NOAA. Layer-2-and-deeper boxes are required to have exactly zero net volume change (their volume is fixed) but all boxes still pass nonzero flow through, so that water moves through each box even when it is impossible for that box's volume of water to change.

Dye is used in the simulation to represent contamination. Dye is transported by upwind (donor-box) advection over whatever flow the potential-flow solve produces: on each connection, material takes on the concentration of whichever box the flow is leaving. This is the only transport mechanism for contamination -- there is no separate diffusion term layered on top. Time-stepping is fully implicit, so that each box's mass balance is solved simultaneously with every other box's, rather than one box or one connection at a time.

The sim_5 Python code, an input template in excel, and a “how-to” word document is available for anyone who wishes to reproduce these results or run different simulations. Links to these files are in the main report.

5.3 Input Template

Model inputs are maintained in a structured spreadsheet (excel) template. The inputs are reproduced in this document in the tables at the back (Section 9), described as follows.

- Table 1 -- Global Parameters: tidal range, tidal period, layer thickness, timestep, number of tidal cycles, starting water level, initial spill concentration, the tide station reference, and vertical exchange and velocity fraction values described in Section 5.5.
- Table 2 -- Stack Dimensions: plan dimensions, footprint area, and layer count for each of the five stacks.
- Table 3 -- Horizontal Connections by Alternative: every horizontal connection between boxes. Separate opening areas for ORIG and MIRP allows the two alternatives to share one engine and one set of physical throttles while differing only in which connections exist and how large they are.
- Table 5 -- Mixing Coefficients (m): a per-box, per-alternative structure for future site-specific mixing tuning. The mixing coefficients were held at 1.0 throughout this study, meaning they had no effect on the comparison.

5.4 Standard Validation Checks

Three checks are built into the engine and run automatically on every simulation:

- Mass conservation -- total system mass plus cumulative mass exited to Bay equals the initial mass, to numerical tolerance.
- Bounds -- concentration remains within $[0, C_0]$ in every box at every timestep.
- Monotonic mass loss -- total system mass never increases from one step to the next.

All three checks passed on every simulation presented in this report.

5.5 Velocity Fraction and Vertical Exchange Fraction (VEF)

Two throttles are applied to the potential-flow conductance. They represent physical effects not otherwise captured by basin geometry alone.

Velocity fraction is a horizontal-conductance multiplier applied at Layer 2 and deeper, representing the combined effect of bottom and wall friction reducing horizontal flow with depth. The values used throughout Sections 6 and 7 of this report are:

Layer	1	2	3	4	5
velocity_fraction	1.0 (inert)	0.7	0.5	0.3	0.3

A roughly 3:1 progression from Layer 1 to Layer 4 was chosen to reflect the combined effect of bottom and wall friction on subsurface flow.

Vertical exchange fraction (VEF) is a vertical-conductance multiplier applied between layers within a stack, representing that a stack's raw cross-sectional area substantially overstates real vertical mixing capacity, which is limited by turbulent eddy size and bottom

friction rather than free to move as a solid slug through the full footprint. VEF is 0.05 for both flood and ebb. It is applied identically to both alternatives and biases neither.

As mentioned, a throttle for mixing (m) is available but not used in this analysis.

6. Validation Testing

Two validation tests were conducted on the simulation engine, summarized here.

6.1 Circulation Pattern Sanity Checks

The engine's box-by-box and layer-by-layer clearing behavior was checked against a set of physically reasoned expectations. All six expectations held:

- Layer 1 clears fastest and Layer 4 clears slowest of all layers, at every checkpoint tested, in both alternatives.
- NW4 is the single slowest-clearing box in the system at every checkpoint tested, in both alternatives -- the same finding was reconfirmed by every point-source scenario in Section 7.
- NEN4 clears more slowly under MIRP than under ORIG. This is traced to NEN's direct connection to C being entirely absent under MIRP (Section 5.1). It is not merely to an indirect loss of an alternate route.
- NES, the most highly connected “crossroads” box, clears before NW and NEN under MIRP at every checkpoint tested.
- S1 and S2 clear faster under MIRP than under ORIG, because they no longer feed the deeper S3/S4 layers that exist only in ORIG.
- Flow direction from interior boxes toward Bay during ebb, and its reversal during flood, was confirmed on every connection traced. This is a consequence of the tide-driven potential-flow that sim_5 solves with Bay held at zero potential. It is not a scripted or hard-coded behavior.

6.2 NES3 Dye Impulse Test

A single-timestep validation test was conducted at NES3 under ORIG. All boxes are six sided and NES3 under ORIG has exactly six connections, all to other fixed-volume boxes. At a mid-flood and a mid-ebb timestep, NES3's water was instantaneously replaced with pure dye (all other boxes at zero) and one implicit transport step was taken using the engine's own resolved flow field. Results:

- Mass was conserved to floating-point precision (relative error $\sim 3 \times 10^{-16}$) on both test steps.

- Dye moved into each of NES3's neighbors in direct proportion to the volume of flow it received that step; neighbors with no inflow that step showed exactly zero dye.
- Flow direction on all six connections correctly reversed between the mid-flood and mid-ebb tests.
- Small second-ring propagation (dye appearing one hop beyond NES3's direct neighbors) was traced to real, simultaneously active connections rather than to any solver artifact.

Both timesteps passed.

Combined with Section 6.1, these tests confirm the engine moves dye in the correct direction, in the correct proportion to resolved flow, with exact mass conservation, at both the single-step and multi-cycle level.

7. Point-Source Spill Scenarios

7.1 Methodology

Four plausible spill locations were selected to represent the basin's structurally distinct regions: NW1 (the surface layer above the system's persistent worst-clearing corner), NEN1 (the surface layer of the stack that loses its direct Bay-ward connection under MIRP), NES1 (the most highly connected “crossroads” location), and S1 (the surface layer of the stack that gains a structural advantage under MIRP). All four are Layer-1 boxes and each has identical volume in both alternatives.

For each location, a dye concentration of 100,000 ppm (10%) is introduced instantaneously at $t = 0$ into that single box only, with every other box starting clean. Because the spill box's volume does not differ between alternatives, both start with an identical total quantity of dye by construction -- no correction for basin-size differences is required. Results are reported as remaining dye quantity in actual cubic feet (concentration $\times$ volume $\div$ 1,000,000), not as a percentage, so that ORIG and MIRP are compared on a common, directly meaningful scale throughout.

For each scenario, two summary metrics are reported: the crossover point (the time after which one alternative permanently holds less residual dye than the other, if this occurs), and the time each alternative takes to reduce its remaining dye to 1% of the spilled quantity – 1% is treated here as a practical “effectively clean” threshold -- together with which single box holds the most residual dye in each alternative at that moment.

7.2 Summary of All Four Scenarios

Spill location	Dye Q ₀ (cuft)	Crossover	ORIG to 1%	MIRP to 1%	Worst box @ 1%
NW1	27,000	0.5 days (immediate)	7.7 d	8.2 d	NW4 / NW4
NEN1	14,400	0.5 days (immediate)	7.1 d	7.6 d	NW4 / NW4
NES1	9,600	1.9 days	7.1 d	7.2 d	NW4 / NW4
S1	50,000	never (MIRP leads throughout)	6.6 d	4.1 d	NW4 / NW4

In every one of the four scenarios, the worst-performing single box -- the one holding the most residual dye when each alternative reaches its own 1% mark is NW4. This is true in both alternatives regardless of where the spill originated. It is the same finding as reported in Section 6.1. It is now confirmed under four independent starting conditions using the parameters in Section 5.5.

7.3 NW1 Spill Test Results

- MIRP holds more residual dye than ORIG at essentially every point in the run; the crossover is effectively immediate (about 0.5 days in), not a late-stage reversal.
- ORIG reaches the 1%-remaining mark in 7.7 days (185.0 hr); MIRP takes 8.2 days (196.3 hr) -- about 11 hours longer.
- The worst-performing box at that point is NW4 in both alternatives (ORIG 0.22% of spilled concentration remaining, MIRP 0.26%).
- NW1 is both the spill location and the surface layer directly above the system's persistent worst-clearing corner -- dye introduced here has the shortest distance to travel to reach the slowest part of the system.

Selected trajectory: Table 7 (Section 9).

7.4 NEN1 Spill Test Results

- Same immediate, persistent MIRP-behind pattern as NW1, but the gap is larger in both absolute and relative terms.
- ORIG reaches 1% in 7.1 days (170.8 hr); MIRP takes 7.6 days (182.5 hr) -- roughly 12 hours longer.
- Reflects NEN's direct connection to C being entirely absent under MIRP (Section 5.1): a spill placed directly at the disconnected box exposes that structural loss more sharply than a spill at NW1, which is one hop further removed from it.
- Worst box at 1%: NW4 in both alternatives (ORIG 0.10%, MIRP 0.13%).

Selected trajectory: Table 8 (Section 9).

7.5 S1 Spill Test Results

- Opposite pattern from NW1 and NEN1: MIRP leads ORIG (holds less residual dye) at every single checkpoint from the first day onward; no crossover occurs at all within the window tested.
- MIRP reaches the 1% mark in just 4.1 days (97.8 hr); ORIG takes 6.6 days (159.3 hr) -- MIRP clears this spill roughly 38% faster.
- Reflects that S1 and S2 no longer have to feed the deeper S3/S4 layers under MIRP (those layers do not exist there) and drain more directly toward Bay as a result.
- Worst box at 1%: NW4 in both alternatives (ORIG 0.23%, MIRP 0.27%) -- even though the spill originated on the opposite side of the basin from NW4, the same bottleneck box governs the tail in every scenario tested. This does not conflict with MIRP leading throughout: ORIG and MIRP reach their own system-wide 1% threshold at very different elapsed times (6.6 days versus 4.1 days), so NW4 -- the slowest box in both alternatives -- has had substantially more time to drain by ORIG's later checkpoint than by MIRP's earlier one.
- This result, MIRP leads ORIG, is a real-world example of the effect of Bay fill... every tide exchanges a fixed volume of water, so the more you fill the bay the faster the bay gets cleaned.

Selected trajectory: Table 9 (Section 9).

7.6 NES1 Spill Test Results -- Movements and the Crossover Concept

NES1 is used here to illustrate, in more depth than the other three scenarios, how and why a crossover happens -- because unlike NW1 and NEN1 (where MIRP is behind from virtually the first step) and unlike S1 (where MIRP leads throughout), NES1 shows both phases within a single scenario.

NES1 sits at a junction connecting to C, NEN, NW, and S -- more connections than any other Layer-1 location tested, consistent with its role as the basin's "crossroads." In the first one to two days after the spill, ORIG and MIRP track very closely, with the lead itself fluctuating (cycle 1: ORIG 5,361 cuft vs. MIRP 5,373 cuft; by cycle 3, MIRP is slightly ahead at 2,278 cuft versus ORIG's 2,285 cuft). This early phase is dominated by the same effect that drives the whole-inlet tidal prism result in Section 4: most of the dye is still local to NES1 and its immediate neighbors, not yet dispersed into the slower interior, and MIRP's smaller basin volume gives it a proportionally larger tidal exchange relative to its water column at this stage.

The persistent crossover occurs at 1.9 days (44.8 hr, cycle 3.6). From that point onward, ORIG holds less residual dye than MIRP for the remainder of the run (through the longest

window tested, roughly 23 days). This is the moment the dye's residence shifts character: from “recently spilled and still near the point of entry” to “settled into the slow-draining interior corner” -- specifically NW2 at the moment of crossover itself (ORIG 0.59%, MIRP 0.89%), migrating to NW4 by the time each alternative reaches its own 1% mark (ORIG 0.06%, MIRP 0.09%). Once the dye is dominated by the NW corner, MIRP's structural deficits there -- the severed NEN-C connection and the loss of the S3/S4 relief pathway that used to give NES extra parallel routes toward Bay -- become the dominant factor, and ORIG's advantage grows and persists for good.

- ORIG reaches 1% at 7.1 days (169.8 hr); MIRP at 7.2 days (172.0 hr) -- a modest gap (about 2 hours) compared to NW1/NEN1, consistent with NES1's well-connected “crossroads” position partially insulating it from MIRP's structural weaknesses.
- This scenario is the clearest illustration in the dataset of the two competing effects at work throughout this report: a whole-basin, geometry-driven advantage for MIRP that dominates early, and a localized, connectivity-driven advantage for ORIG that dominates once the dye reaches the NW/NEN corner.

Selected trajectory: Table 10 (Section 9).

8. Conclusions

The tidal prism analysis predicts that MIRP flushes faster than ORIG based only on the basin's total volume and the assumption of complete, instantaneous mixing each cycle. Taken at face value, this result implies MIRP flushes faster everywhere.

The multi-box simulation shows the tidal prism analysis paints an incomplete picture. MIRP's advantage holds only for the point-source spill nearest its own structural strength (S1), where it cleans faster with no crossover at all. For the other three spill locations tested (NW1, NEN1, NES1), ORIG clears the spill faster: immediately and persistently for NW1 and NEN1, and after an early, brief MIRP advantage that reverses within two days, for NES1. ORIG wins three of the four spill locations tested; MIRP wins only the fourth.

Across every scenario tested -- all four spill locations, both alternatives, and the validation testing in Section 6 -- the single slowest-clearing box in the system is consistently NW4, regardless of where the spill originated. This points to NW4 as a structural bottleneck of the basin's overall geometry (a corner box several connections removed from open water in both alternatives) rather than a defect specific to either design, though MIRP's version of that bottleneck is measurably worse than ORIG's in most scenarios tested. The bottom line: the trough created by MIRP's stepped bottom adds to a weak point in the system.

9. Tables

Table 1. Global Parameters

Parameter	Value
H_layer_ft	2
Tidal_range_ft	5.84
Tidal_period_hrs	12.4
Num_tidal_cycles (template default)	10
Delta_t_minutes	15
Start_sim_from_MLLW_ft	0
NOAA_Station_ID	9414290
Visitor_Dock_draft_ft	1
Initial_conc_ppm	100,000
Vertical_exchange_fraction_Flood	0.05
Vertical_exchange_fraction_Ebb	0.05
Velocity_fraction_L1 (inert)	0.9
Velocity_fraction_L2	0.7
Velocity_fraction_L3	0.5
Velocity_fraction_L4	0.3
Velocity_fraction_L5	0.3

Table 2. Stack Dimensions

Stack	W (ft)	D (ft)	Num. layers	Plan area (sf)
C	100	300	5	30,000
NEN	400	180	4	72,000
NES	400	120	4	48,000
NW	450	300	4	135,000
S	500	500	4 (ORIG); 2 (MIRP)	250,000

Table 3. Horizontal Connections by Alternative (abridged)

Connection ID, endpoints, layer, opening type, and opening area for each alternative.
Direction and length columns from the input template are omitted here for space. The full table is retained in the input template.

Conn. ID	From	To	Layer	Type	Area ORIG	Area MIRP
H_C_Bay	C1	Bay	1	TIDE_VAR	200	200
H_C_Bayb	C2	Bay	2	FIXED	200	200
H_C_Bayc	C3	Bay	3	FIXED	200	200
H_C_Bayd	C4	Bay	4	FIXED	200	200
H_C_Baye	C5	Bay	5	FIXED	200	200
H_C_NEN	C1	NEN1	1	TIDE_VAR	360	0
H_C_NENb	C2	NEN2	2	FIXED	360	0
H_C_NENc	C3	NEN3	3	FIXED	360	0
H_C_NENd	C4	NEN4	4	FIXED	360	0
H_C_NES	C1	NES1	1	TIDE_VAR	240	240
H_C_NESb	C2	NES2	2	FIXED	240	240
H_C_NESc	C3	NES3	3	FIXED	240	240
H_C_NESd	C4	NES4	4	FIXED	240	240
H_NEN_NW	NEN1	NW1	1	TIDE_VAR	360	360
H_NEN_NWb	NEN2	NW2	2	FIXED	360	360
H_NEN_NWc	NEN3	NW3	3	FIXED	360	360
H_NEN_NWd	NEN4	NW4	4	FIXED	360	360
H_NES_NW	NES1	NW1	1	TIDE_VAR	240	240
H_NES_NWb	NES2	NW2	2	FIXED	240	240
H_NES_NWc	NES3	NW3	3	FIXED	240	240
H_NES_NWd	NES4	NW4	4	FIXED	240	240
H_NEN_NES	NEN1	NES1	1	TIDE_VAR	800	800
H_NEN_NESb	NEN2	NES2	2	FIXED	800	800
H_NEN_NESc	NEN3	NES3	3	FIXED	800	800
H_NEN_NESd	NEN4	NES4	4	FIXED	800	800
H_C_S	C1	S1	1	TIDE_VAR	200	200
H_C_Sb	C2	S2	2	FIXED	200	200

H_C_Sc	C3	S3	3	FIXED	200	0
H_C_Sd	C4	S4	4	FIXED	200	0
H_NES_S	NES1	S1	1	TIDE_VAR	400	400
H_NES_Sb	NES2	S2	2	FIXED	800	800
H_NES_Sc	NES3	S3	3	FIXED	800	0
H_NES_Sd	NES4	S4	4	FIXED	800	0

Table 4. Tidal Datums (NOAA CO-OPS Station 9414290, San Francisco, CA)

Tidal epoch 1983-2001; datums accepted 2003-04-17.

Datum	Elevation re: MLLW (ft)	Elevation re: Station Datum (ft)	Description
MHHW	5.84	11.82	Mean Higher-High Water
MHW	5.23	11.21	Mean High Water
MTL	3.18	9.16	Mean Tide Level
MSL	3.12	9.1	Mean Sea Level
DTL	2.92	8.9	Mean Diurnal Tide Level
MLW	1.13	7.11	Mean Low Water
MLLW	0	5.98	Mean Lower-Low Water (model reference datum, 0 ft)
NAVD88	-0.06	5.92	North American Vertical Datum of 1988

Source: NOAA CO-OPS station 9414290 (San Francisco, CA, Golden Gate), <https://tidesandcurrents.noaa.gov/datums.html?id=9414290> . Elevations re: MLLW are the station-datum value minus the MLLW station-datum value (5.98 ft), so that MLLW = 0.00 ft - consistent with the Start_sim_from_MLLW_ft convention used throughout the simulation input template and sim_5.py. As a cross-check, MHHW - MLLW = 5.84 ft, matching the Tidal_range_ft parameter (Great Diurnal Range) already used in Table 1.

Table 5. Mixing Coefficients (m)

m is held at 1.0 for every box in both alternatives (no effect on results); the table structure is retained in the input template for future site-specific tuning.

Table 6. Point-Source Scenario Summary

Spill location	Dye Q _o (cuft)	Crossover	ORIG to 1%	MIRP to 1%	Worst box @ 1%
NW1	27,000	0.5 days	7.7 d	8.2 d	NW4 / NW4
NEN1	14,400	0.5 days	7.1 d	7.6 d	NW4 / NW4
NES1	9,600	1.9 days	7.1 d	7.2 d	NW4 / NW4
S1	50,000	never	6.6 d	4.1 d	NW4 / NW4

Full per-scenario trajectories are given in Tables 7-10.

Table 7. NW1 Point-Source Trajectory

Cycles 1-10, then every second cycle through cycle 44.

Cycle	Hours	ORIG remaining (cuft)	MIRP remaining (cuft)	MIRP vs. ORIG (%)
1	12.5	18986.24	19309.54	1.7
2	24.8	12804.45	13417.36	4.8
3	37.2	8812.09	9382.26	6.5
4	49.5	6186.64	6650.51	7.5
5	62.0	4415.22	4780.33	8.3
6	74.5	3199.97	3487.2	9.0
7	86.8	2349.49	2577.41	9.7
8	99.2	1744.53	1927.29	10.5
9	111.5	1308.34	1456.36	11.3
10	124.0	988.54	1109.21	12.2

12	148.8	574.8	656.11	14.1
14	173.5	339.61	394.8	16.3
16	198.5	202.51	239.97	18.5
18	223.2	121.39	146.73	20.9
20	248.0	72.98	90.04	23.4
22	272.8	43.94	55.36	26.0
24	297.5	26.48	34.08	28.7
26	322.5	15.95	20.99	31.6
28	347.2	9.61	12.93	34.5
30	372.0	5.79	7.97	37.6
32	396.8	3.49	4.91	40.7
34	421.5	2.1	3.03	44.0
36	446.5	1.27	1.86	47.3
38	471.2	0.76	1.15	50.7
40	496.0	0.46	0.71	54.3
42	520.8	0.28	0.44	57.9
44	545.5	0.17	0.27	61.6

Table 8. NEN1 Point-Source Trajectory

Cycles 1-10, then every second cycle through cycle 44.

Cycle	Hours	ORIG remaining (cuft)	MIRP remaining (cuft)	MIRP vs. ORIG (%)
1	12.5	7229.42	8123.87	12.4
2	24.8	4714.83	5276.54	11.9
3	37.2	3214.37	3603.29	12.1
4	49.5	2243.69	2528.47	12.7
5	62.0	1594.36	1808.82	13.5
6	74.5	1151.6	1316.61	14.3
7	86.8	843.19	972.27	15.3
8	99.2	624.62	726.9	16.4
9	111.5	467.5	549.38	17.5
10	124.0	352.6	418.56	18.7
12	148.8	204.4	247.76	21.2
14	173.5	120.47	149.16	23.8
16	198.5	71.69	90.7	26.5
18	223.2	42.9	55.47	29.3
20	248.0	25.76	34.04	32.2
22	272.8	15.49	20.93	35.1
24	297.5	9.32	12.89	38.2
26	322.5	5.61	7.94	41.4
28	347.2	3.38	4.89	44.6
30	372.0	2.04	3.01	47.9
32	396.8	1.23	1.86	51.4

34	421.5	0.74	1.14	54.9
36	446.5	0.44	0.71	58.6
38	471.2	0.27	0.43	62.3
40	496.0	0.16	0.27	66.1
42	520.8	0.1	0.17	70.1
44	545.5	0.06	0.1	74.1

Table 9. S1 Point-Source Trajectory

Cycles 1-10, then every second cycle through cycle 44.

Cycle	Hours	ORIG remaining (cuft)	MIRP remaining (cuft)	MIRP vs. ORIG (%)
1	12.5	30048.83	22620.39	-24.7
2	24.8	18682.21	10852.66	-41.9
3	37.2	12046.9	5482.95	-54.5
4	49.5	8017.01	2937.45	-63.4
5	62.0	5474.29	1677.32	-69.4
6	74.5	3824.38	1024.32	-73.2
7	86.8	2722.05	665.12	-75.6
8	99.2	1967.62	454.72	-76.9
9	111.5	1441.2	323.73	-77.5
10	124.0	1066.08	237.18	-77.8
12	148.8	597.5	134.68	-77.5
14	173.5	342.28	79.67	-76.7
16	198.5	198.87	48.07	-75.8

18	223.2	116.65	29.29	-74.9
20	248.0	68.89	17.94	-74.0
22	272.8	40.88	11.02	-73.0
24	297.5	24.34	6.78	-72.1
26	322.5	14.52	4.17	-71.3
28	347.2	8.68	2.57	-70.4
30	372.0	5.2	1.58	-69.5
32	396.8	3.12	0.98	-68.7
34	421.5	1.87	0.6	-67.8
36	446.5	1.12	0.37	-67.0
38	471.2	0.67	0.23	-66.1
40	496.0	0.41	0.14	-65.3
42	520.8	0.24	0.09	-64.4
44	545.5	0.15	0.05	-63.5

Table 10. NES1 Point-Source Trajectory

Cycles 1-10, then every second cycle through cycle 44.

Cycle	Hours	ORIG remaining (cuft)	MIRP remaining (cuft)	MIRP vs. ORIG (%)
1	12.5	5361.18	5373.11	0.2
2	24.8	3437.18	3415.59	-0.6
3	37.2	2285.03	2278.35	-0.3
4	49.5	1561.09	1570.38	0.6
5	62.0	1089.96	1109.57	1.8

6	74.5	775.98	801.0	3.2
7	86.8	561.36	588.33	4.8
8	99.2	411.59	438.33	6.5
9	111.5	305.32	330.53	8.3
10	124.0	228.46	251.45	10.1
12	148.8	130.66	148.6	13.7
14	173.5	76.15	89.4	17.4
16	198.5	44.9	54.34	21.0
18	223.2	26.67	33.23	24.6
20	248.0	15.91	20.39	28.1
22	272.8	9.52	12.54	31.7
24	297.5	5.71	7.72	35.2
26	322.5	3.43	4.75	38.7
28	347.2	2.06	2.93	42.3
30	372.0	1.24	1.8	45.9
32	396.8	0.74	1.11	49.5
34	421.5	0.45	0.69	53.2
36	446.5	0.27	0.42	57.0
38	471.2	0.16	0.26	60.8
40	496.0	0.1	0.16	64.7
42	520.8	0.06	0.1	68.7
44	545.5	0.04	0.06	72.8

10. Figures

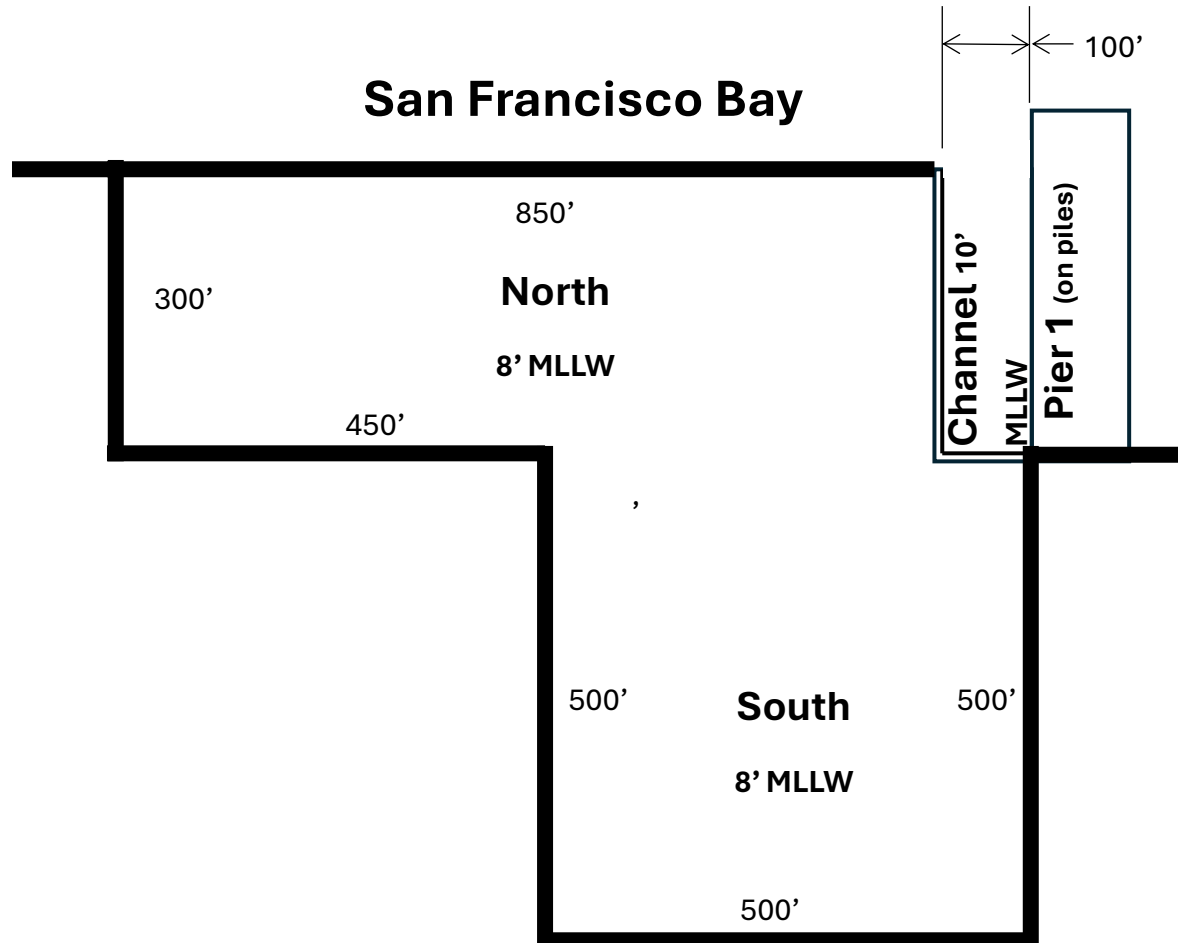


Figure A 1: ORIG

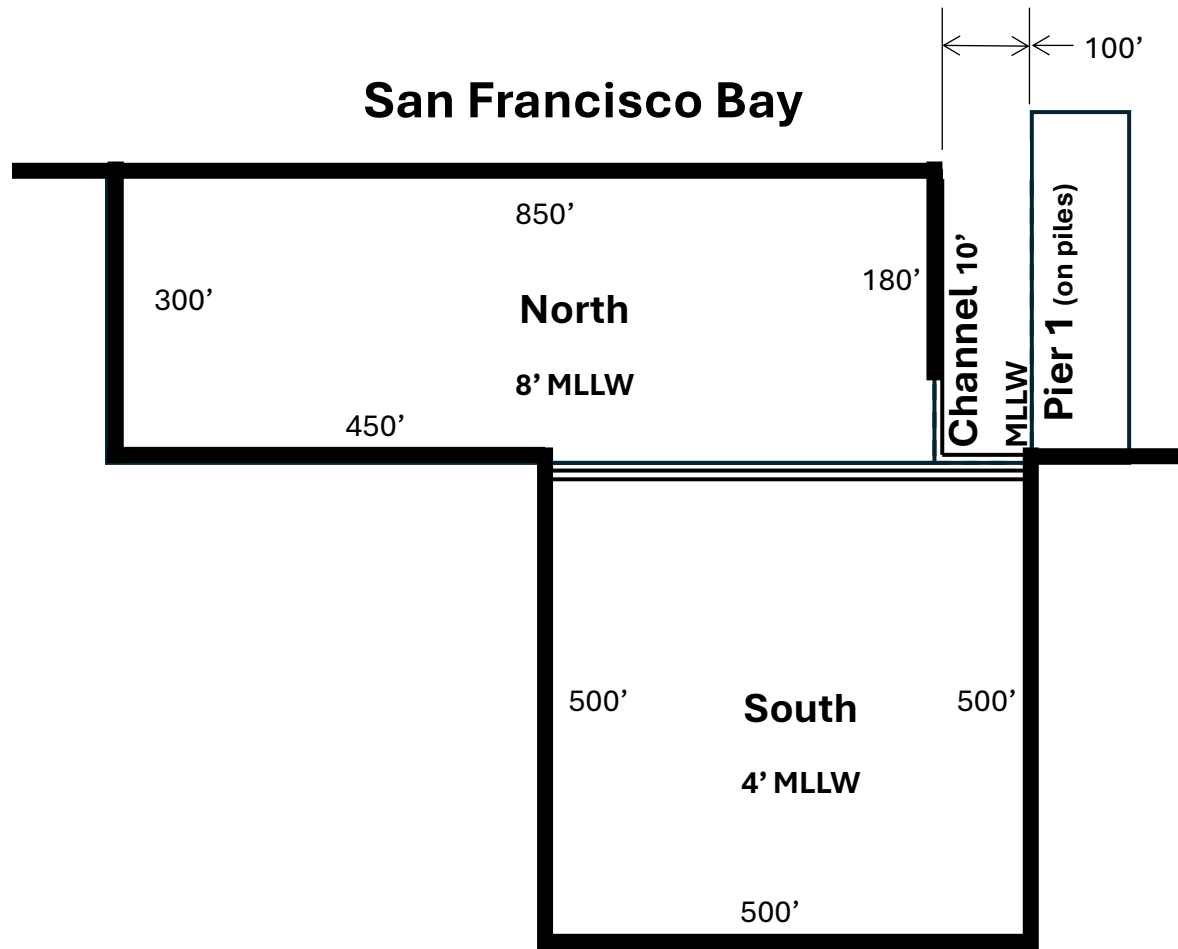


Figure A 2: MIRP

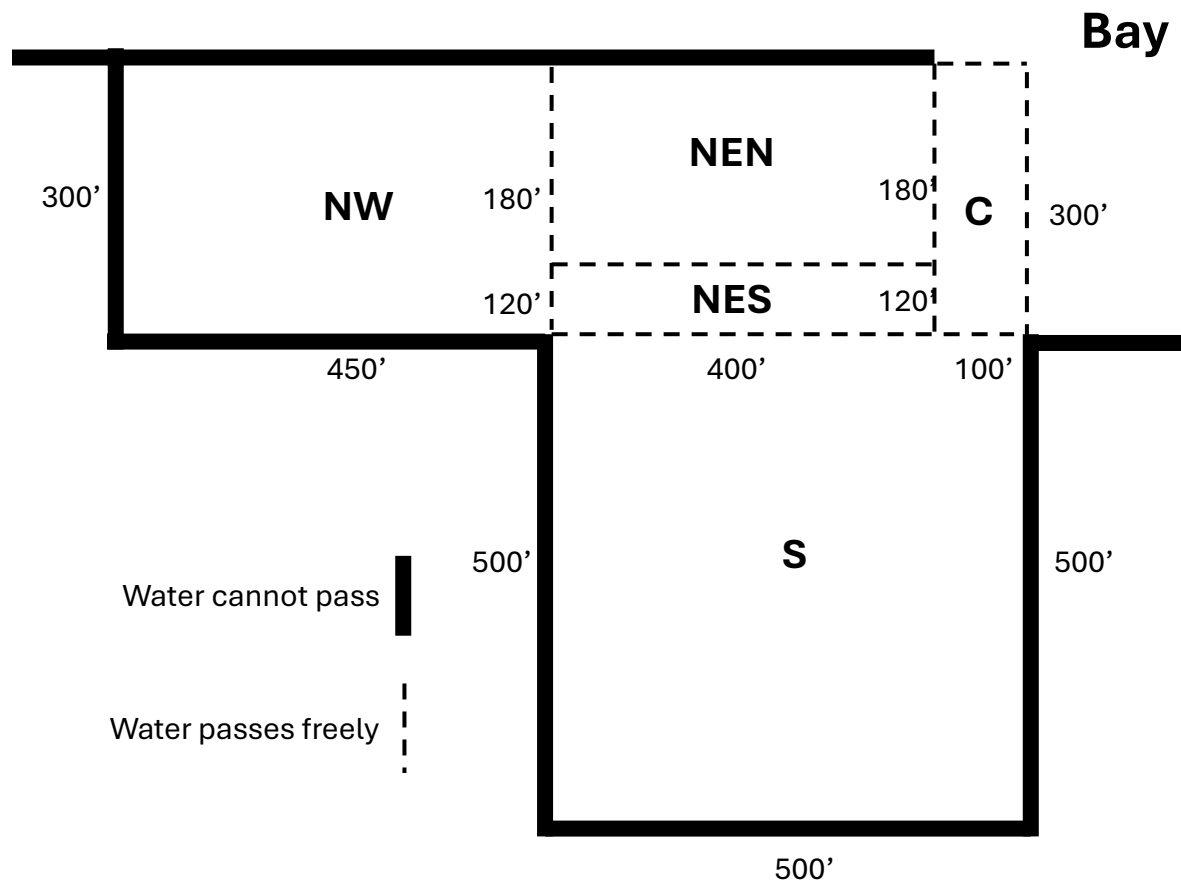


Figure A 3: ORIG partitions

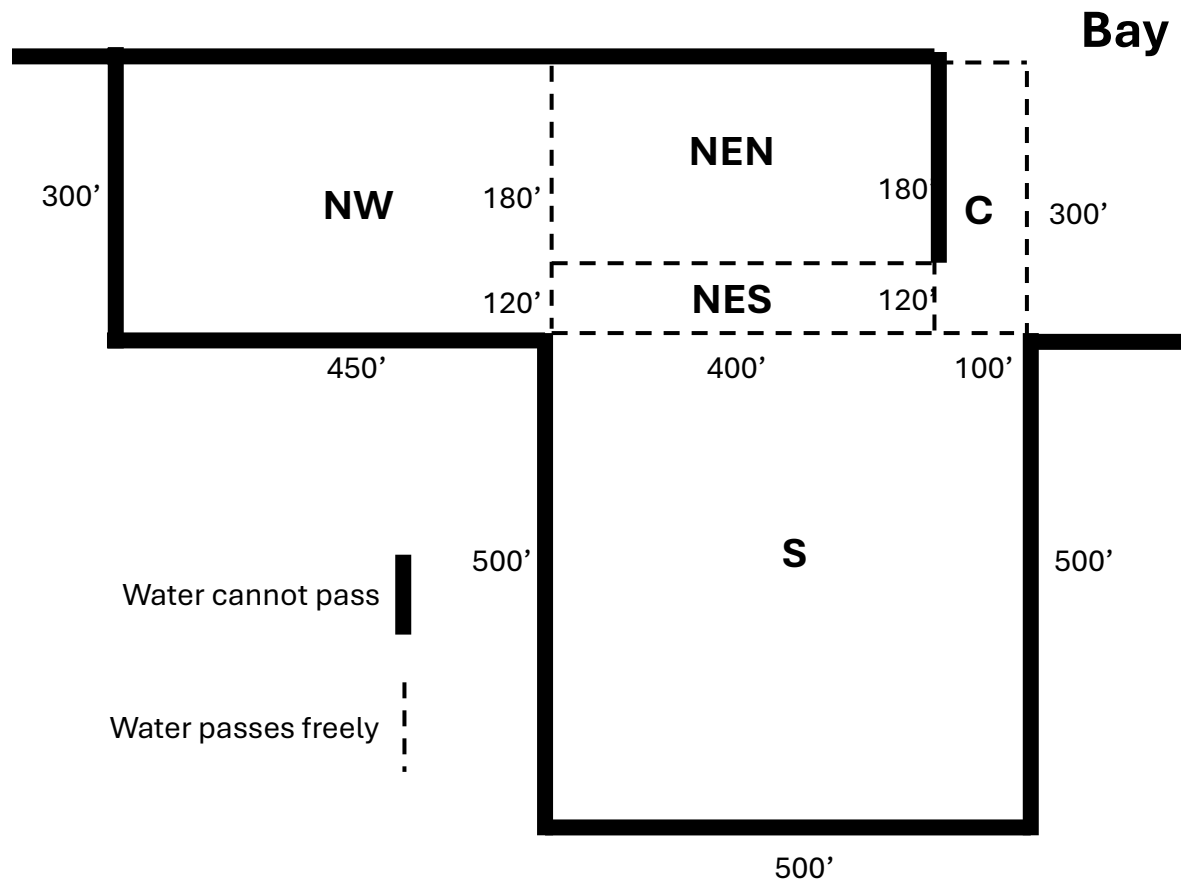


Figure A 4: MIRP partitions

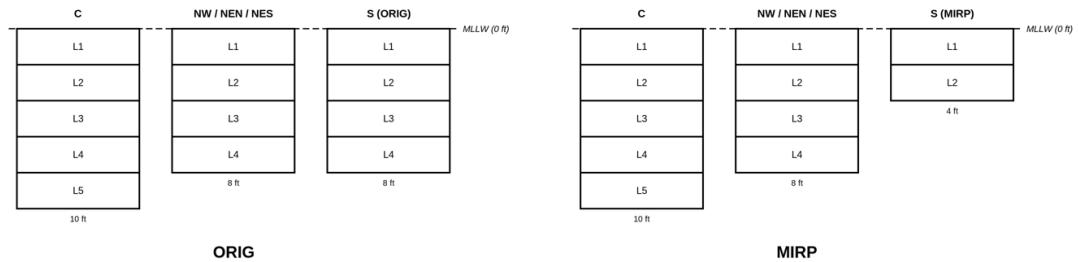


Figure A 5: Stacks, Layers, and Boxe

End Notes

- ¹ See Figures A1 and A2 of the attachment for illustrations, dimensions, and terminology.
- ² Another report expressed skepticism on the practicality, the applicants' intention, and capability of keeping South dredged to 4' MLLW. In this view, South will become shallower and shallower over time, eventually becoming a mudflat. Nonetheless, this report assumes 4' MLLW.
- ³ Cold water holds more dissolved oxygen than warm because of fundamental physics and chemistry of gas solubility.
- ⁴ For example, MHHW – MLLW was used for tidal forcing every cycle which is significantly more aggressive than the more realistic MHW – MLW. The selection speeds up the simulation w/o impacting which alternative is faster, but the real-world cleaning times should be much longer.
- ⁵ It can be made less simple and more precise by increasing the number of boxes but it will not change the outcome. 21 boxes was sufficient to prove winners and losers.
- ⁶ Sim_5 is capable of using mixing coefficients but selecting the values is a judgment bound to stir argument. More sophisticated simulations will be needed to demonstrate the expected poor mixing in the trough to the detriment of the MIRP.
- ⁷ Although its determination has not been formally finalized at this writing, the Water Board has approved a feasibility study and is in process of approving a remedial action plan for the MIRP. Conversations with Water Board personnel indicate there are no significant impediments and full approval is anticipated.
- ⁸ The amount that seeps into Bay water is expected to be small but persistent.
- ⁹ 20210600 June PGE Updated Community Notice.pdf [[Link](#)]
- ¹⁰ 20230601 A B Map of 20211221 Exhibit 5 Revised [[Link](#)]
- ¹¹ 20120000 MGP contamination bubbling in Gashouse Cove [[Link](#)]
- ¹² 20230218 Gashouse Cove Sheen 37 sec Video Bubbling [[Link](#)]
- ¹³ 20260130 PGE IRM Report Gashouse Cove Q4 2025 [[Link](#)]
- ¹⁴ 20160428 Leidos Project Description for IRM_SF Marina East Harbor_28Apr16 [[Link](#)]
- ¹⁵ 20160520 Gashouse Cove RWQCB Concurrence with IRM black bubbles Seep [[Link](#)]
- ¹⁶ 20260429 Gashouse Cove RAP pdf pg 16 [[Link](#)]
- ¹⁷ The author estimates the IRM seep is connected to a football field sized, 20' thick deposit of continuous and discontinuous NAPL mostly westward.
- ¹⁸ The barriers are both physical and legal. The vast majority of the 50+ Marina properties remediated thus far have clean fill or concrete over deeper chemical deposits and Land Use Covenants, a legal barrier related to liability. The philosophy behind PG&E's M. O. has been traced back to the mid-1980s: 19860320 PGE ltr to EPA [[Link](#)].
- ¹⁹ Of the 100% of chemicals existing beneath Gashouse Cove and that are feasible to remove, the MIRP removes 15%. Should the Flat Bottom contour advocated elsewhere be selected, 45% would be removed. It is never 100% removed, and that's not including chemicals in the uplands which are untouched. The amount of chemicals remaining are vast. The amounts entering are small, instantly diluted, impossible to measure, but there are always some entering into Gashouse Cove.
- ²⁰ 20260429 Gashouse Cove RAP at pdf pg 16 [[Link](#)]
- ²¹ 20180927 Revised Consent Decree.pdf [[Link](#)]. This is a consent decree between PG&E and the San Francisco Herring Association. The author is not a party to this consent decree.
- ²² Feasibility studies have estimated the amount of sediment that can be feasibly removed from beneath Gashouse Cove and differentiated it by the amount that can be beneficially reused, meaning uncontaminated, and the amount that required special treatment, meaning contaminated. The amount requiring special treatment is 241,000 cubic yards.

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- ²³ 19700409 RP-078-70-3 [[Link](#)]
- ²⁴ 19720623 RP-078-72-1.jpg [[Link](#)]
- ²⁵ 19620115 Area D RP-078-62-1-31.tif [[Link](#)]
- ²⁶ Private conversations with the Water Board led to this discovery. It is known that the Water Board regularly specifies engineered caps to protect chemicals. When asked for examples of natural sediment being approved as a protective layer over chemicals, the Water Board could not find any that have been approved in the Bay Area RWQCB (it is not known if it has been approved in other regions).
- ²⁷ Private conversations
- ²⁸ Private conversations, oft repeated statement.
- ²⁹ All possible other uses must be for shallow water or no water (fill) because the area deeper than 4' MLLW has been dedicated to chemical storage.
- ³⁰ 20221231 Laguna Street Sewer Outfall.MOV [[Link](#)]
- ³¹ 20190219 PIERCE STREET OUTFALL (CSD-010) CLOSURE TECHNICAL MEMO (2) (1).pdf at pdf pgs 3 and 12. [[Link](#)]
- ³² 20190611 SFPUC SSIP CSD 10 Pierce Street Receiving Water Analysis (June 11, 2019). Confirms receiving water quality analysis for Gashouse Cove was not completed for the storm event in which Laguna discharges as a result of Pierce closure. [[Link](#)]
- ³³ 20240501 US and CA sue SF over CWA violations [[Link](#)]
- ³⁴ SF Bay Plan, Policies: 3 Recreation facilities, b Marinas (3) "*No new marina or expansion of any existing marina should be approved unless water quality and circulation will be adequately protected and, if possible, improved, and...*" pdf pg 79 [[Link](#)]
- ³⁵ SF Bay Plan, Water Surface Area and Volume, Policies 1. Pdf pg 29.
- ³⁶ SF Bay Plan, Water Quality, Findings and Policies Concerning Water Quality in the Bay, Findings, g.. pdf pg 27.
- ³⁷ 20230307 OEH FS.PDF [[Link](#)]
- ³⁸ 20260112 RPD to BCDC Permit ap 3 modified Encl D.Remediation_30P (1) pdf pg 7 [[Link](#)]