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SLEEPY HOLLOW STEELHEAD REARING FACILITY
SEDIMENT CONTROL AND INTAKE RETROFIT

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

**LIST
ENGINEERING
COMPANY**

9699 Blue Larkspur Lane
Suite 203
Monterey CA 93940

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Introduction

The California American Water Company is under State of California instructions to change the way they operate the San Clemente dam. The change in operation will lower the dam water level and is scheduled to begin on May 15, 2003. With the reduced water level, there will be an increase in the amount of sand and silt released into the river below the dam. This additional sediment will have a negative impact on the water intake system at the Sleepy Hollow Steelhead Rearing Facility.

In order to be prepared for the change in the river water quality, a design – build team is preparing to revise the river intake and water delivery system at the SHSRF. The schedule for this work is limited and includes obtaining permits, long lead-time materials and complete construction prior to the end of April.

Design goals for the project are:

- Prevent silt from entering the rearing channel and contaminating the fish rearing environment.
- Reduce wear damage to pumps.
- Improve the District's ability to maintain the river water pumps.

Findings

Existing Operations:

1. The Facility has an existing 10" dia. stainless steel river water inlet. This inlet floods a single pump enclosure that houses two submersible pumps. Each pump operates on a weekly basis when the Rearing Facility is in operation. This is normally between May and December. The alternate pump serves as a backup pump. An electrical generator provides backup power.
2. A pump delivers 900 GPM of water through a 6" pipe to a meter, strainer, cooling tower and cold well. The cooling tower operates only as required to maintain water temperature. Three submersible pumps located in the cold well deliver the water to the rearing channel and holding tanks.
3. Problems have occurred when river sediment fouled the mechanical seals at the submersible pumps. Access to the pumps for maintenance is limited, and the back-up pump can not be operating while the other pump is being serviced.

Contributing Factors:

Pumps:

The solution should improve the protection of the pumps from the sediment contained in the river water.

There are four means available to protect the pumps:

1. Remove the sediment from the river water prior to the pumps. See Alternates 1, 2, 3, 6, and 8.
2. Use intake water that does not contain sediment. See Alternates 4, 5 and 7.
3. Use a pump that does not rely on mechanical seals to protect the motor. See pump discussion below.
4. Add vanes to the top of the pump impeller. Rotating vanes aid in keeping suspended silt away from the mechanical seal.

Existing pumps can be revised to utilize a chair rail type pump removal system to improve pump access. Furthermore, the addition of a third pump on-site would improve back-up capability when a pump is removed for maintenance.

Sediment:
In order for a settling still well to be effective, water requires 1 minute detention at less than 1 FPS velocity to allow sand to settle. Additional time and/or lower velocity is necessary to settle the silt component. Furthermore, it would be best if the basin were large enough to hold an entire season silt and sand in order to avoid having to clean the clarifier during the period of rearing channel usage or have the ability to automatically clean itself. For additional protection, a centrifugal separator can be installed after the pumps.

Sediment will pass the Rearing Facility in two modes: moving bedload and suspended. Bedload consists of sand and silt distributed on the river bed that will over time, sluff down the river during periods when the river is flowing with enough energy to break the material loose. Suspended sediment is the material that makes the water 'cloudy'.

Studies are being performed by others to predict the quantity of bedload and suspended sediment that may occur in the river when the dam level is reduced. The modeling results vary depending on the judgment factors of the annalist. The varying results effects this project only in predicting the amount of spoils that will be removed by any type of settling pit or clarifier. Preliminary estimate of sediment loading indicates between 0 and 125 tons per year with average values ranging from 10 to 40 tons per year when the facility is operating at low level.

Bedload will be factor during the winter storms, but the rearing facility is usually not in use during this period. The one exception is a scenario is a large storm at the very beginning of the rainy season prior to the fish being released back to the river. See Appendix D for additional information.

It is the suspended material that is of most concern, as it will always be entrained into the pump enclosure. See Appendix E for additional information.

Using an overflow value of 30,000 GPD/ft^2, approximately 80 ft^2 of clarifier area would remove 98% of the particles 150 microns or larger. This constitutes what is typically referred to as grit or sand. A basin 10 times larger in area would have minimal increase in performance and only remove particles classified as course silt. A basin approximately 200,000 ft^2, or 5 acres, would be necessary to remove all silt at 900 GPM flow. See Appendix F.

Source of Water:

Currently, the facility pumps surface water from the river through the rearing channel and returns the water downstream from the water intake.

Use of ground water, whether from a deep well, Ranney collector or in bank filtration relies on the earth itself to filter sand and sediment from the water stream. It may also impact water chemistry with low dissolved oxygen, high carbon dioxide and other minerals that may be different from river water and effect the fish. Ground water temperature will tend to be more constant that river water temperature and require increased use of the cooling tower for temperature control.

Pump Technology:

The existing pump site is prone to high river level water damage. This required a design that could withstand the high flows and this meant the use of a submersible pump. The submersible pump relies on mechanical seals, among other features, to protect the pump motor from the river water. It is the sand and silt in the river water that scores the seals and creates a major problem.

A wet pit, column type pump places the motor above ground and relies on a long shaft to turn the pump impeller. Because the motor is not adjacent to the impeller, there are no mechanical seals. A bushing is used to support the impeller loads and this is not subject to the same tolerances as a mechanical seal. There are intermediate shaft bearings to maintain that require lubrication. Proper installation is critical for shaft/bearing alignment. The motor also has to be installed in a location that is not subject to high river water damage. Pump removal is difficult due to the long shaft.

Additional Considerations:

All materials used in construction must be consistent with chemical requirements of the fish habitat. Zinc galvanizing is not allowable if in contact with the river water.

Holding water for any length of time in the summer will raise the temperature of the water, meaning the cooling tower will see a higher inlet temperature. Other than additional cooling tower operating time, this should not pose a problem.

Site access will be a concern during the winter due to the high water level at the river crossing.

Any proposed solution cannot exceed the existing power requirements at pumps due to the existing electrical design.

A Johnson Screens, Inc. river inlet screen with a backwash feature will be used at intake pipe.

District will provide necessary Corps of Engineers, California Department of Fish and Game and NOAA National Marine Fishery Services permits. The Design team will assist with Monterey County permit.

Care must be exercised at all construction locations to minimize damage to (e) trees.

A centrifugal separator is a devise that uses the kinetic energy in a fluid stream to remove suspended particles. Locating a centrifugal separator ahead of the cooling tower will remove most of the silt from the water and protect the rearing channel but not the river pumps. In order to operate a centrifugal separator, the 6" supply main must be replaced. The (e) main is approximately 220' long. New pipe to be 10" dia. PVC, similar to Mansville Blue Brute.

If the centrifugal separator is used, it could be placed between the cold well and the rearing channel. This would eliminate any debris picked up at the cooling tower and assure clean water going to the channel. It would also impact the cold well pump selection by increasing the head requirement at the three (e) pumps. Separator will be placed above ground on a new concrete pad. Separator blowdown must be piped to a safe discharge location.

New pump enclosure will:

1. Contain two pumps, quick disconnect pump base with rail motor /impeller removal system and isolation valve(s) for improved pump maintenance.
2. Pump revisions to include the addition of vanes on the backside of the impeller to reduce silt build-up around the mechanical seal.
3. Be 8' diameter, precast concrete with concrete base and hinged and bolted cover.

Alternate 1 – Divider Wall and Additional Pump Enclosure:

1. Add a second pump housing adjacent to the (e) pump housing along the river shore.
2. Rebuild (e) pump housing with a solid concrete base, add river water inlet shut off valve.
3. Relocate one of the two (e) pumps to the new pump housing.
4. Construct a divider in the river which locates the water intake within a stilling well of adequate volume to allow sand and silt to settle.
5. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.

6. Provide centrifugal separator ahead of cooling tower to remove silt from water and protect the rearing channel.

Alternate 1 improves pump protection from sand or silt by creating a still well in the river.

Alternate 2 – Open Excavation Settling Pit:

1. Use (e) pump enclosure and river water intake. Connect to back side of enclosure and extend to new pit.
2. Provide an open excavation settling pit with perimeter protection.
3. Construct (n) pump housing to draw river water from settling pit.
4. Revise (e) river water inlet.
5. Relocate and revise (e) pumps.
6. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.
7. Provide centrifugal separator ahead of cooling tower to remove silt from water and protect the rearing channel.

In order for the settling pit to be effective, an approximate plan area of 80 sq ft would be necessary to remove 100% of grit particles (150 microns or greater in diameter). To remove all particles classified as sand (62 microns or larger), a plan area of approximately 460 sq ft would be required. To remove particles in the coarse silt range, the settling area would need to increase to approximately 4,500 sq ft. Even with this area, silt removal will not be complete.

Alternate 3 – Concrete Settling Pit:

1. Use (e) pump enclosure and river water intake. Connect to back side of enclosure and extend to new pit.
2. Construct a (n) concrete settling pit complete with perimeter protection and grating.
3. Construct (n) pump housing to draw river water from settling pit.
4. Revise (e) river water inlet.
5. Relocate and revise (e) pumps.
6. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.
7. Provide centrifugal separator ahead of cooling tower to remove silt from water and protect the rearing channel.

In order for the settling pit to be effective, a plan area of 400 ft^2 would remove 98% of fine sand. To remove coarse silt, settling area would need to increase to 4,455 ft^2. Even with this area, silt removal will not be complete.

Alternate 4 – Ranney Collector:

1. Retain (e) pump housing with water level equipment in place.

2. Provide a (n) Ranney Method type water filter system. New collector housing to be deep enough to allow horizontal bores. Number of radial bores is unknown at this time.
3. Use of Ranney method is predicated on the successful completion of a hydrogeological survey and 72 hour test to verify the aquifer can continually support the flow demand. The technology relies on permeable, unconsolidated sand and gravel in contact with the river, which is unknown at this time.
4. Relocate (e) pumps.
5. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.

The Ranney Method relies on ground water, does not require a piped connection to the river and provides excellent silt protection. Normally, the Ranney method is not used on a system flowing less than 2,000 GPM. This feature allows more flexibility in locating the collector but also requires more to be known re: the local geology.

Alternate 5 – In Bank Filtration:

1. Retain (e) pump housing with water level equipment in place.
2. Construct multiple, perforated, inlet piping parallel to the river bank and manifold to new pump enclosures.
3. Relocate (e) pumps and revise to include a rail lift mechanism for improved pump removal.
4. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.

This Alternate relies on ground water, does not require a piped connection to the river and provides excellent silt protection. Constructability issues for this Alternate include placing the piping among (e) trees. This method relies on the migration of river water through the alluvial deposits and requires more to be known re: the local geology. The effects of the long term impact on the river channel and variable river elevations leave this Alternate unproven at this time.

Limited field testing at the existing pump enclosure suggests soil hydraulic conductivity is 118 GPD/ft^2. Required facility water flow is 1,296,000 GPD. This suggests that at a minimum, 10,983 ft^2 of contact area is required. Presuming a one foot wide by one foot deep trench for the collector pipe, over 2,750 lineal feet of piping will be required. This does not consider a possible reduction in hydraulic conductivity further away from the river or the impact of placing collector pipes in parallel. This would approximate a collector field measuring 50' across and 460'. Excavation for this field would be 80' by 480' and the site isn't this large.

Alternate 6 – Buried Riverbed Intake:

1. Retain (e) pump housing with water level equipment in place.
2. Move pumping station toward the rearing facility and construct (n) pump housing.
3. Provide 80' long excavation in riverbed and new river water intake.
4. Provide an open excavation to the river and a (n) river water intake pipe.

5. Relocate (e) pumps and revise to include a rail lift mechanism for improved pump removal.
6. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.

This Alternate involves extensive permitting review work due to the work within the riverbed.

Alternate 7 –Water from new Cal-Am Russell Wells:

1. Retain (e) pump housing with water level equipment in place.
2. Use the Russell Well field located downstream from SHSRF as the source of water for operations.
3. Extend new supply pipe to Cal-Am raw water pipe coming from two new Russell Wells.
4. Coordinate Russell Well system revisions: Cal-Am to add two new wells, emergency generator and piping revisions in order to provide back-up capabilities.

This Alternate involves extensive permitting review due to the addition of two new wells..

Alternate 8 – Buried Concrete Settling Pit:

1. Retain (e) pump housing with water level equipment in place.
2. Provide a (n) river water inlet.
3. Construct parallel, buried, precast concrete river water clarifiers.
4. Construct a (n) pump housing to draw river water from clarifiers.
5. Relocate and revise (e) pumps.
6. Replace (e) 6" supply pipe to cooling tower with (n) 10" pipe.

Constructing parallel clarifiers will improve reliability of process. Clarifiers can be cleaned by use of a vacuum truck to avoid personnel entering a confined space for manual cleaning. Spoils can be placed on the adjacent grade or trucked offsite.

Conclusions:

Revised submersible pumps will provide better overall performance than the wet pit column type pump alternate.

It is not possible to predict the quantity of sediment that will be removed from the clarifiers or pits. Sand and silt removed can be placed in the adjacent floodway channel and allowed to return to the river when the river level increases. If the quantity of recovered sand exceeds available space, then transporting the sand to another location may be required.

Several of the proposed Alternates may be functionally viable but the time constraints placed on this project preclude adopting.

Alternate 1 will always be problematic due to the location of the pump enclosures and the effect on the river channel. The extensive permit reviews will exceed the available schedule. Alternate 1 is not viable.

Alternate 2 is buildable, relies on low-tech solutions and materials, improves maintenance but is subject to recurring high river damage. The extensive permit review will exceed the available schedule. Alternate 2 is not viable.

Alternate 3 is difficult to construct due to extensive concrete construction. It does rely on low-tech solutions and improves maintenance. The design is subject to extensive permit review, recurring high river damage and is costly to construct. Alternate 3 is not viable.

Alternate 4 will be cost prohibitive with cost estimates ranging between $500K and $1,000K. Required geology is unknown and costly to investigate. Alternate 4 is not viable.

Alternate 5 will require an excessive amount of buried pipe to be reliable. Construction among (e) trees will be problematic. Long-term river channel migration could be a problem. Additional hydrogeological survey and pump testing would be required. Alternate 5 is not viable.

Alternate 6 will be costly to build and the extensive permitting review will exceed the available schedule. Alternate 6 is not viable.

Alternate 7 relies extensively on the California American Water Company. The alternate is costly and requires extensive permit review. Alternate 7 is not viable.

Alternate 8 is buildable, relies on low-tech solutions and materials and minimizes construction work in the river. The buried clarifiers provide protection from high river water levels. Improved maintenance and protection for the pumps is the provided. Minimum permit review is required. Installing clarifiers in parallel provide redundant flow stream for back-up operation, or at the District's choice, both streams can be operated simultaneously for better performance.

Recommendations:

1. Proceed with the design and construction of Alternate 8.
2. Revise (e) pumps to include back vanes and rail removal features.
3. Provide improved access to clarifiers for servicing.
4. Provide third pump to maintenance stores.

SILT CONTROL
SLEEPY HOLLOW STEELHEAD REARING FACILITY

ALTERNATE ANALYSIS

	Alternate 1	Alternate 2	Alternate 3	Alternate 4	Alternate 5	Alternate 6	Alternate 7	Alternate 8
Description	Construct divider in river for stilling well, reuse (e) pump enclosure and add second pump enclosure. Replace (e) river intake screen.	Open excavation stillwell using (e) water intake, one new pump enclosure. Replace (e) river intake screen.	Poured in place concrete settling pit, one new pump enclosures. Replace (e) river intake screen.	Ranney Method ground water collector.	In Bank Filtration	Construct new river water intake within river, one new pump enclosure. Replace (e) river intake screen.	Construct pipeline from CalAm water main	Buried concrete culvert pipe to enclose intake, one new pump enclosure. Replace (e) river intake screen.
Operating Premise	River floods stillwell and pump enclosure, single pump supplies water to cooling tower. Centrifugal filter eliminates silt.	River floods stillwell and pump enclosure, single pump supplies water to cooling tower. Centrifugal filter eliminates silt.	River floods stillwell and pump enclosure, single pump supplies water to cooling tower. Centrifugal filter eliminates silt.	Horizontal bores at base of vertical pump enclosure collect ground water. Ground filters silt. Pump supplies cooling tower.	Ground water adjacent to the river bank infiltrates buried piping. Ground filters silt. Pump supplies cooling tower.	River floods collector pipe located within the riverbed, single pump supplies water to cooling tower. Centrifugal filter eliminates silt.	Water piped to area from Cal Am Russell wells is delivered to cooling tower.	River floods clarified and pump enclosure, single pump supplies water to cooling tower. Centrifugal filter eliminates silt.
Components	Water intake screen, stillwell, two pumps, centrifugal separator.	Water intake screen, stillwell, two pumps, centrifugal separator.	Water intake screen, stillwell, two pumps, centrifugal separator.	Ranney collector, two pumps.	Perforated pipe, two pumps.	Intake screen, stillwell, two pumps, centrifugal separator.	Pipeline.	Water intake screen, stillwell, two pumps, centrifugal separator.
Evaluation Criteria								
Maintenance								
1. Ease of removing removed captured silt	Dredge river stillwell as required.	Dredge stillwell as required.	Dredge stillwell as required.	Not applicable.	Not applicable.	Dredge river as required.	Not applicable	Vacuum clean clarifiers as required.
Rating:	6	7	7	10	10	6	10	9
2. Ease of repairing pumps	Better than existing.	Better than existing.	Better than existing.	Better than existing.	Better than existing.	Better than existing.	Unknown.	Better than existing.
Rating:	5	5	5	5	5	5	9	5
Durability								
3. Ability to withstand high river flow	Stillwell subject to high river flow damage.	Stillwell subject to high river flow damage.	Stillwell subject to high river flow damage.	Not subject to damage.	Not subject to damage.	Stillwell subject to high river flow damage.	Probably.	Probably.
Rating:	3	2	4	9	9	4	9	8
4. Pump reliability	Silt at pump inlet	Silt at pump inlet	Silt at pump inlet	No silt at pump.	Limited silt at pump.	Silt at pump inlet	NA	Silt at pump inlet
Rating:	5	5	5	9	8	5	9	5
Cost								
5. First	NA	NA	NA	NA	NA	NA	$ 600,000.00	$ 500,000.00

SILT CONTROL
SLEEPY HOLLOW STEELHEAD REARING FACILITY

ALTERNATE ANALYSIS

	Alternate 1	Alternate 2	Alternate 3	Alternate 4	Alternate 5	Alternate 6	Alternate 7	Alternate 8
6. Operating	Same as existing	Same as existing	Same as existing	Higher than existing due to additional cooling tower operation.	Higher than existing due to additional cooling tower operation.	Same as existing	Higher than existing. CalAm charges are unknown.	Slightly higher than existing
Rating:	5	5	5	4	4	5	3	5
7. Maintenance	Dredge stillwell.	Dredge stillwell.	Dredge stillwell.	minimum	minimum	Dredge stillwell.	Minimum	Minimum
Rating:	5	5	5	8	8	5	8	5
8. Water	NA	NA	NA	NA	NA	NA	TBD	NA
Rating:	10	10	10	10	10	10	??	10
Operations								
9. Manhours required to operate	Same as existing	Same as existing.	Same as existing.	Less than existing.	Same as existing.	Same as existing.	Less than existing.	Less than existing.
Rating:	5	5	5	7	7	5	7	5
11. Viability of solution	Good	Good	Good	Geology at site is unknown and needs to be proven acceptable.	Geology at site is unknown and needs to be proven acceptable.	Good	Good	Good
Rating:	5	5	5	3	3	5	3	5
Reliability								
12. Design	Simple	Simple	Design is more involved due to amount of concrete detailing.	Design is reliable if geology will support process. Process may not be workable in this location.	Design is reliable if geology will support process. Process may not be workable in this location.	Simple	More involved due to CalAm's operation.	More involved due to concrete and iron detailing.
Rating:	5	5	5	3	3	5	3	5
13. Constructability	Moderate to complex due to riverbed divider.	Simple	More involved due to amount of cast in place concrete.	Very involved due to technology.	Very difficult due to size of collector pipe field.	Very complex due to work in river.	More involved due to required work at CalAm site.	Simple
Rating:	3	5	5	2	2	2	3	5
14. Silt separation	Relies on centrifugal separator.	Relies on centrifugal separator.	Relies on centrifugal separator.	Ground water is self cleaning.	Ground water is self cleaning.	Relies on centrifugal separator.	Ground water is self cleaning.	Relies on centrifugal separator.
Rating:	9	9	9	9	7	9	9	9
15. Back-up water	On-site, under MPWMD control.	On-site, under MPWMD control.	On-site, under MPWMD control.	On-site, under MPWMD control.	On-site, under MPWMD control.	On-site, under MPWMD control.	On-site, under MPWMD control, or off site under CalAm control.	On-site, under MPWMD control.
Rating:	9	9	9	9	9	9	5	9
16. Water safety	NA	NA	NA	Unknown, would need to evaluate ground water quality.	NA	NA	Unknown, must evaluate chemical effect due to piping.	NA
Rating:	9	9	9	8	9	9	8	9

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SILT CONTROL
SLEEPY HOLLOW STEELHEAD REARING FACILITY

ALTERNATE ANALYSIS

	Alternate 1	Alternate 2	Alternate 3	Alternate 4	Alternate 5	Alternate 6	Alternate 7	Alternate 8
Permitting	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, possible Use Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.	Monterey County Grading Permit, COE 404, CDFG 1601, RWQCB 404 Cert.
Rating:	1	8	6	1	8	1	1	8
Unknowns								
16. Water chemistry	NA	NA	NA	Subject to review	NA	NA	Subject to review	NA
17. Water temperature	NA	NA	NA	Warmer, will require additional cooling tower operation.	NA	NA	Warmer, will require additional cooling tower operation.	NA

Conclusion	Not viable due to permitting process.	Not viable due to ongoing maintenance.	Not viable due to length of construction, ongoing maintenance, permitting process.	Not viable due to cost and length of construction.	Not viable due to site constraints and unknown geology.	Not viable due to permitting process	Not viable due to cost and permitting process	Buildable

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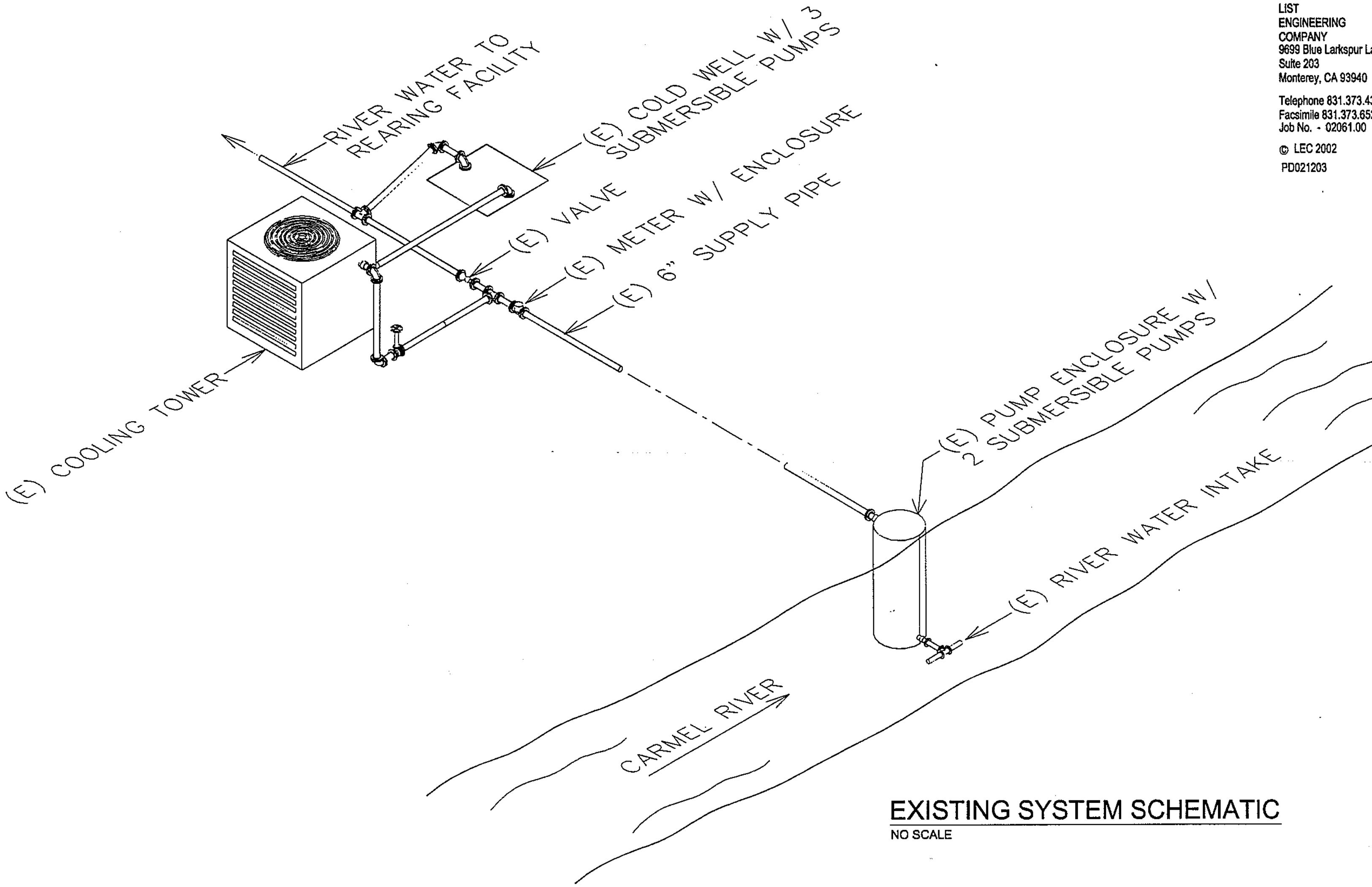

EXISTING SYSTEM SCHEMATIC

NO SCALE

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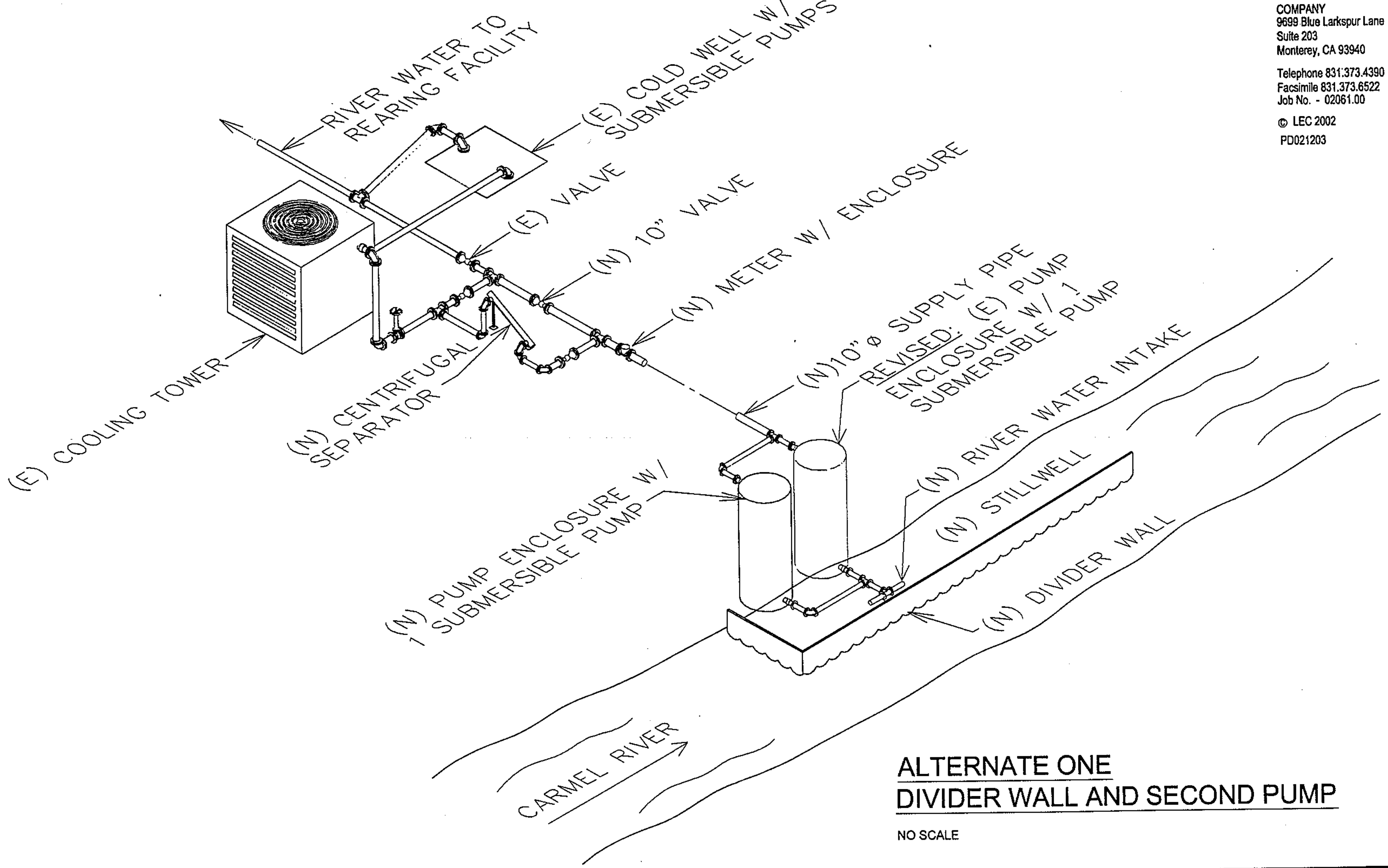

ALTERNATE ONE
DIVIDER WALL AND SECOND PUMP

NO SCALE

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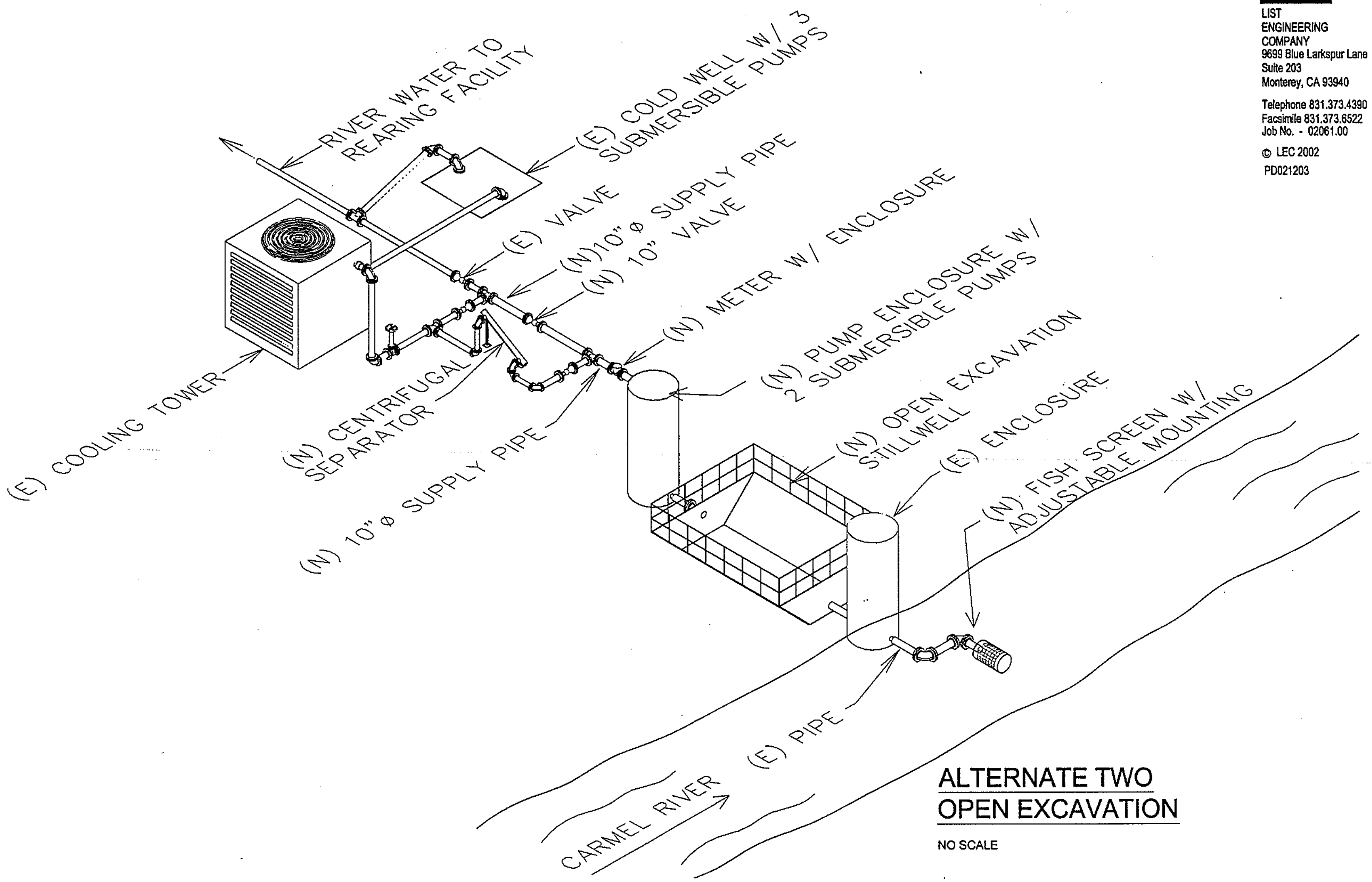
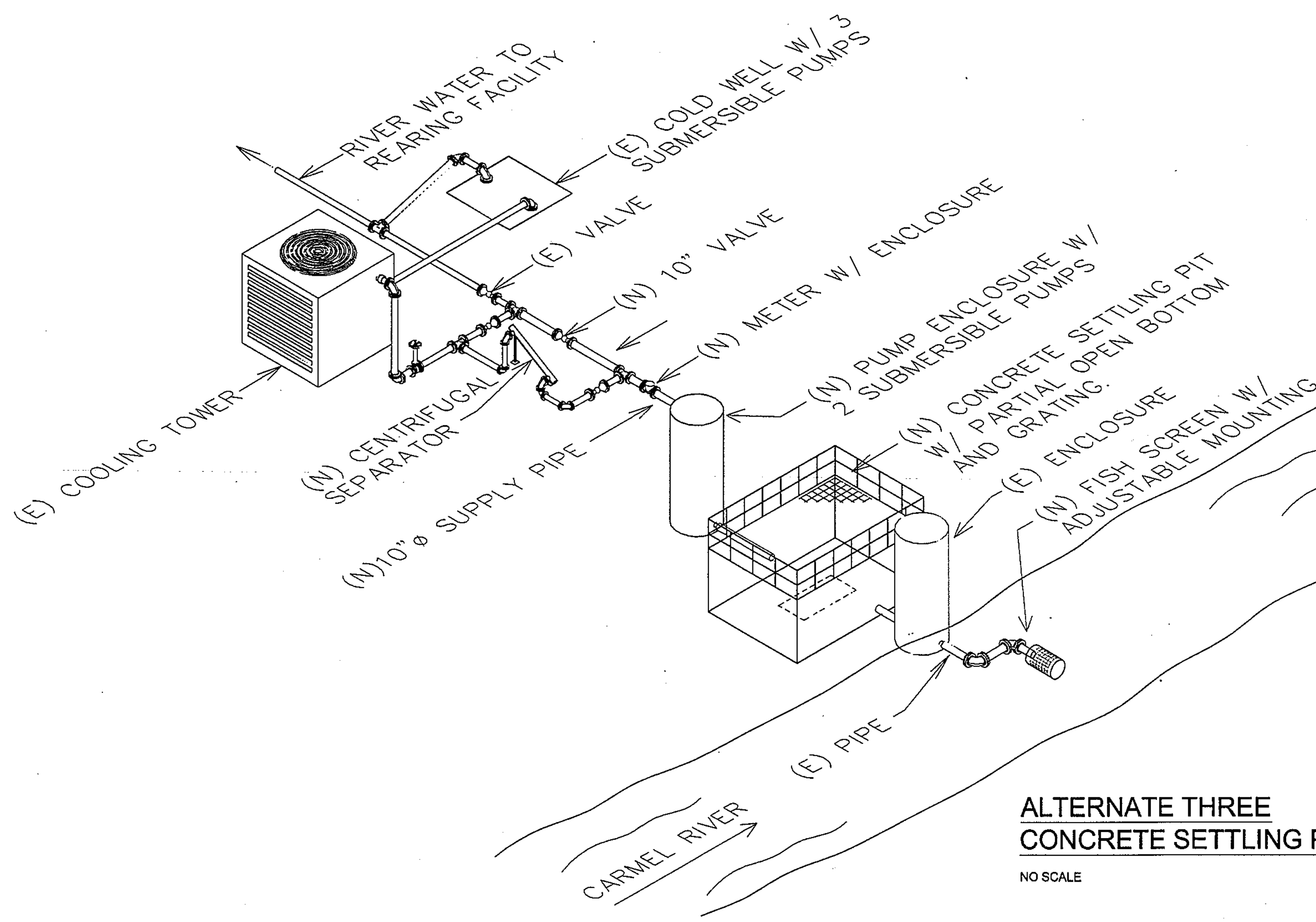


ALTERNATE TWO
OPEN EXCAVATION

NO SCALE



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ALTERNATE THREE
CONCRETE SETTLING PIT

NO SCALE

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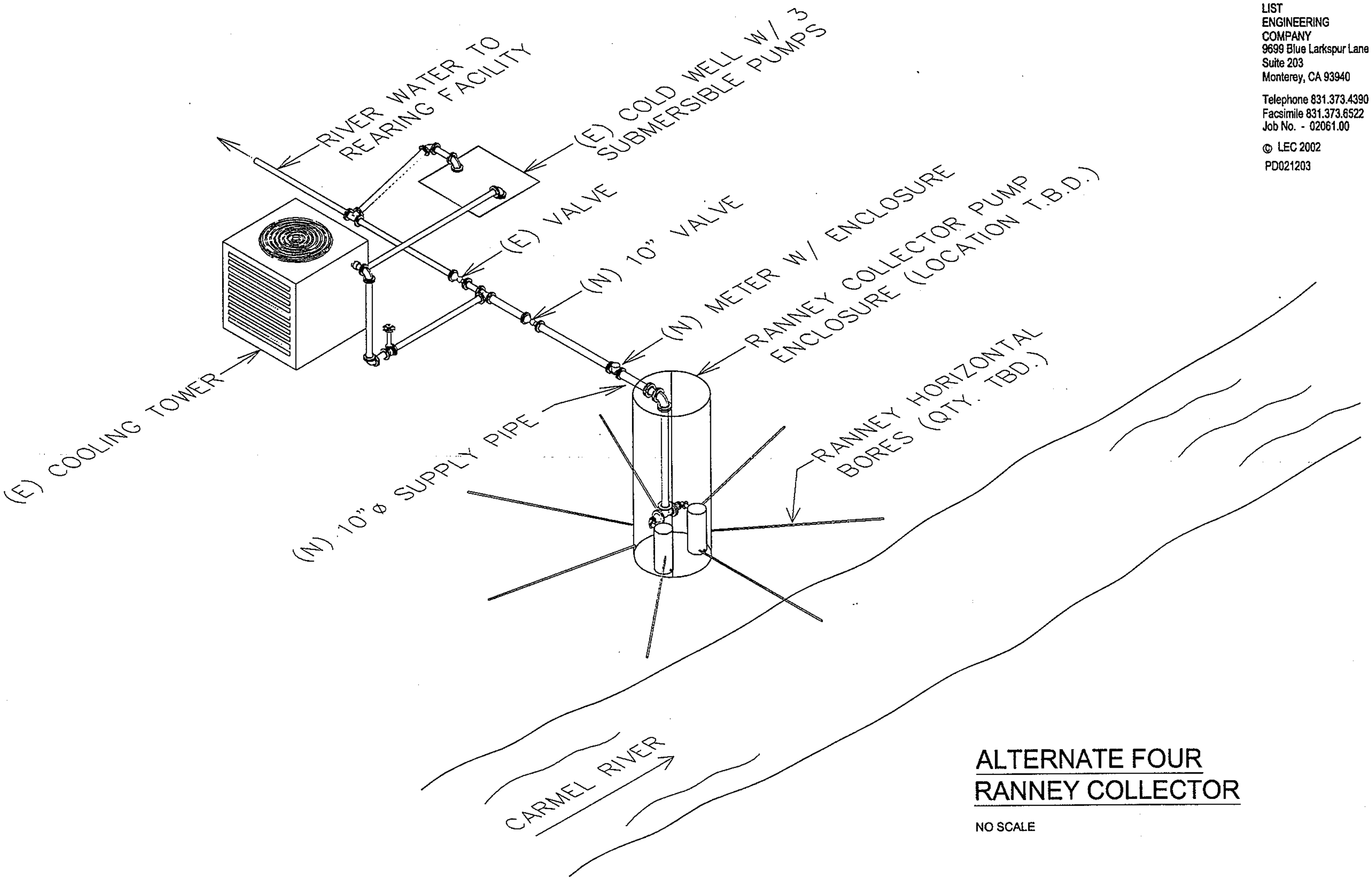
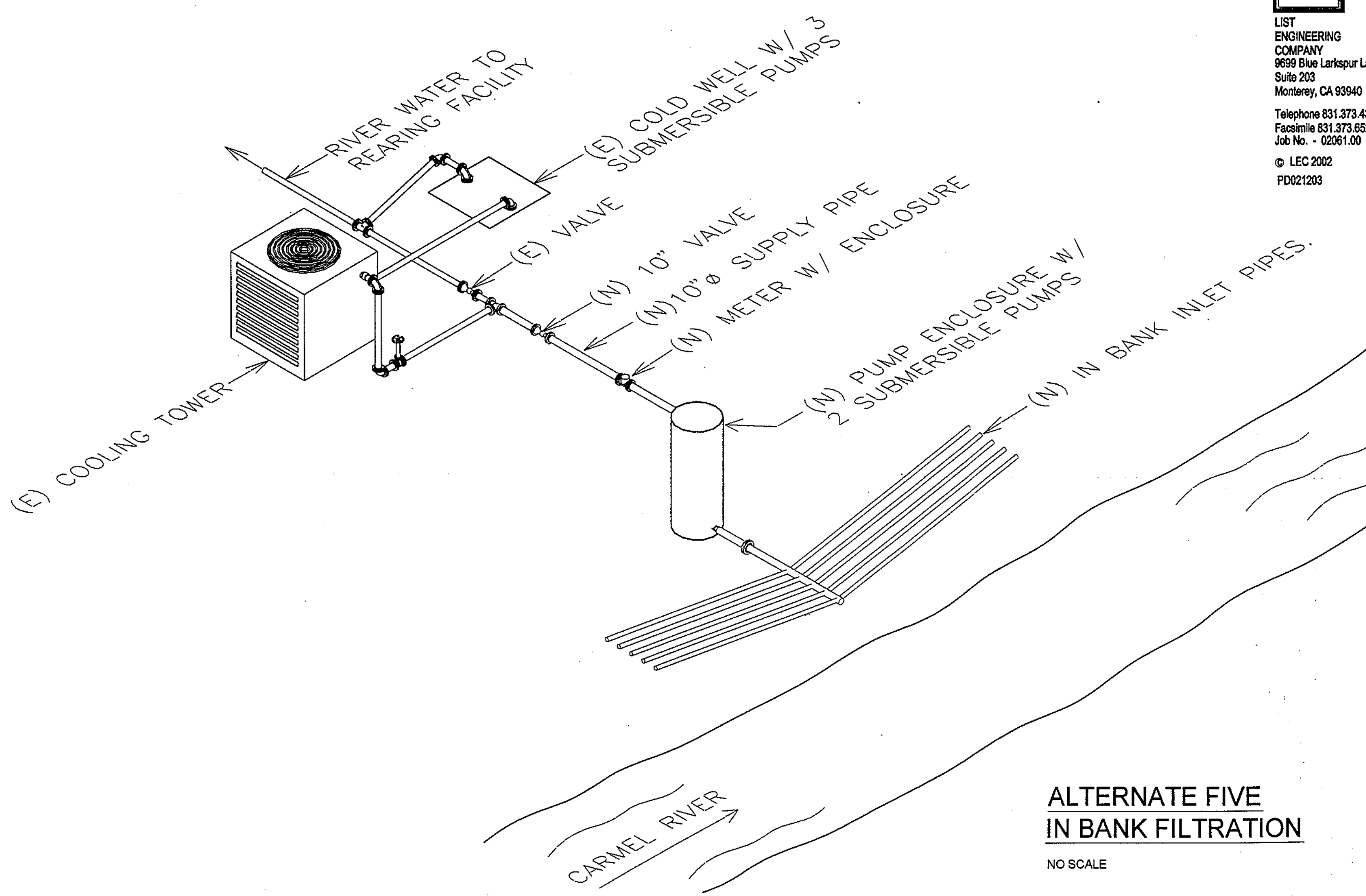


ALTERNATE FOUR
RANNEY COLLECTOR

NO SCALE



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ALTERNATE FIVE
IN BANK FILTRATION

NO SCALE

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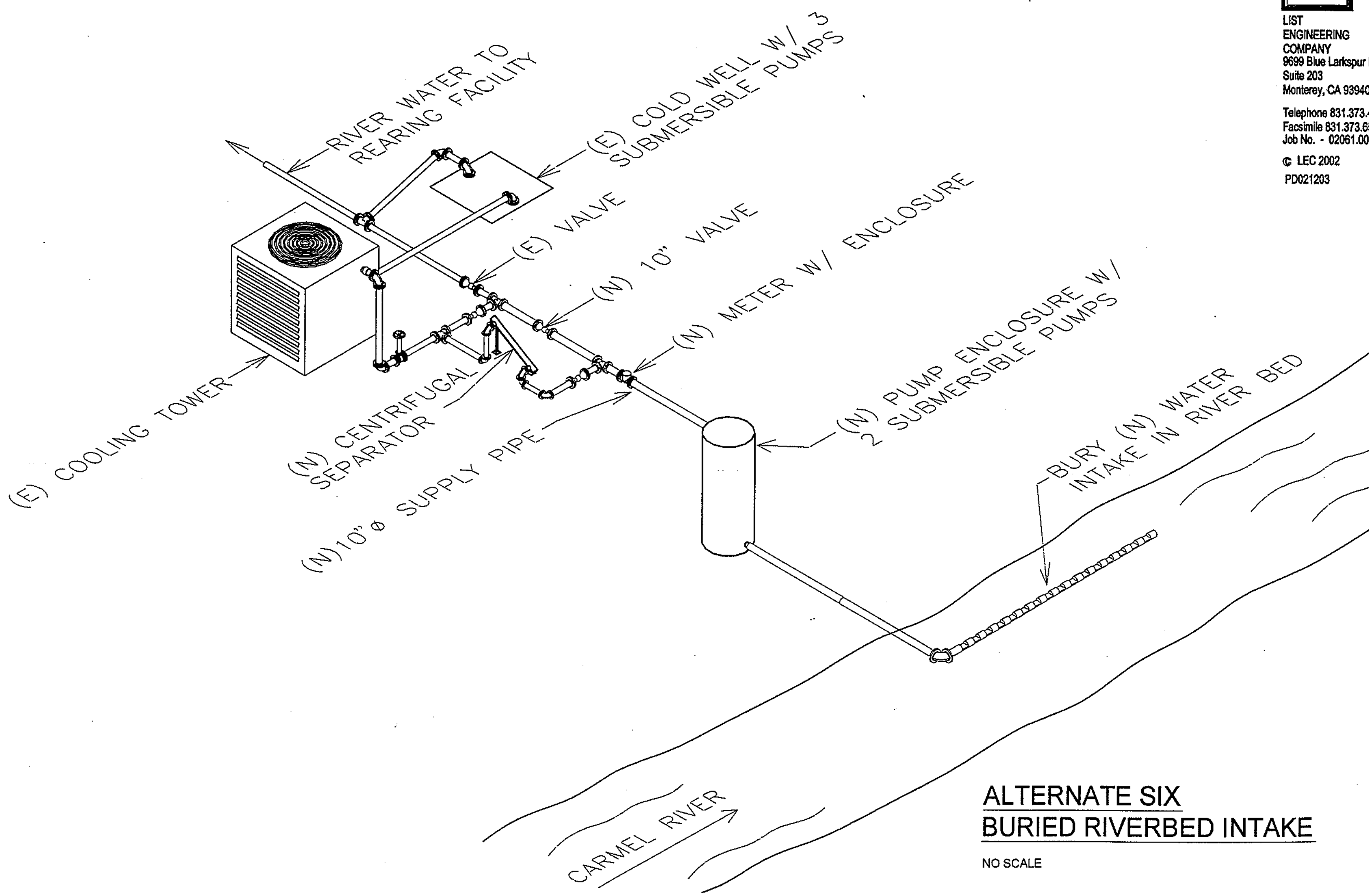

ALTERNATE SIX
BURIED RIVERBED INTAKE

NO SCALE

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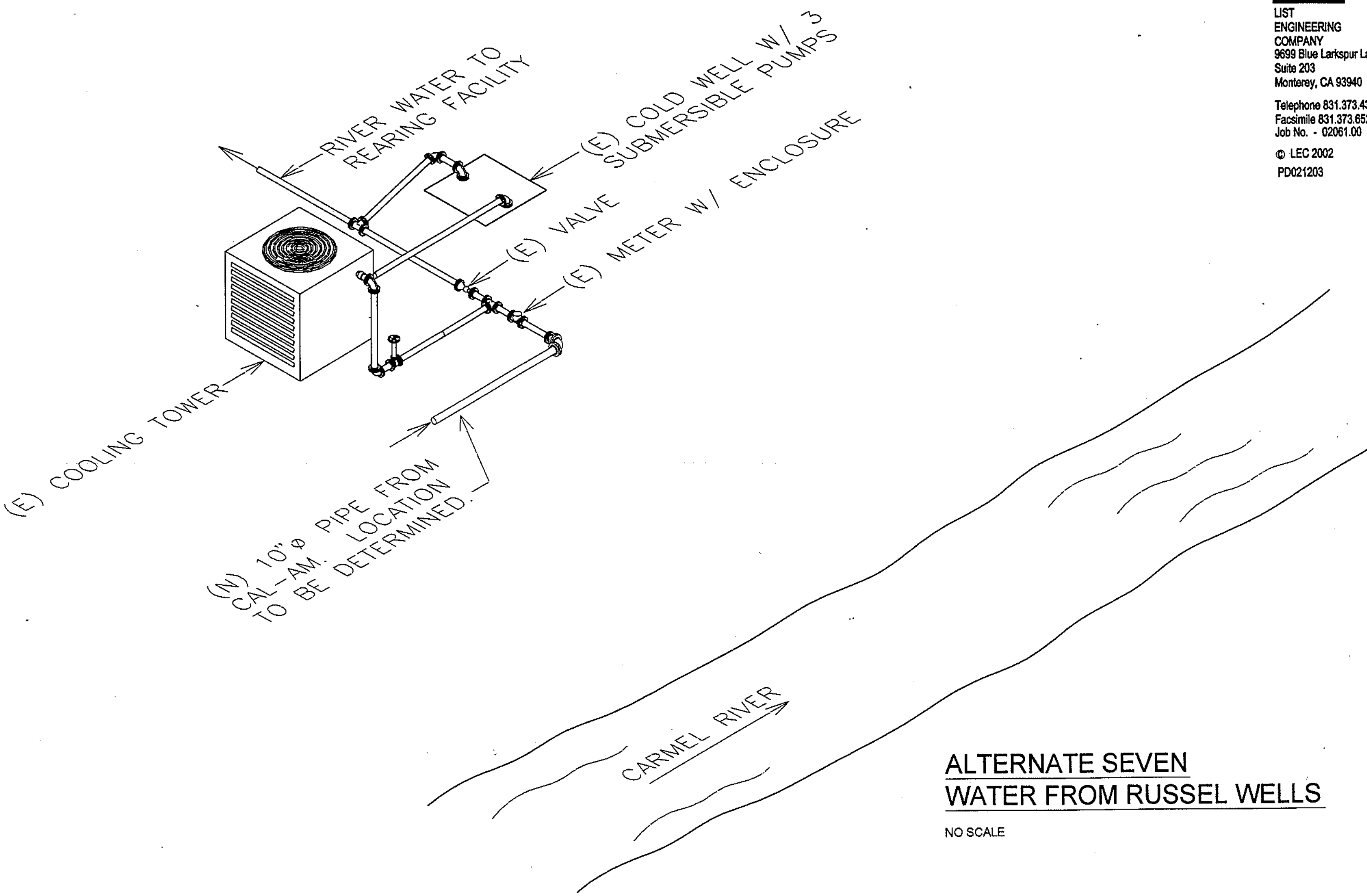

ALTERNATE SEVEN
WATER FROM RUSSEL WELLS

NO SCALE

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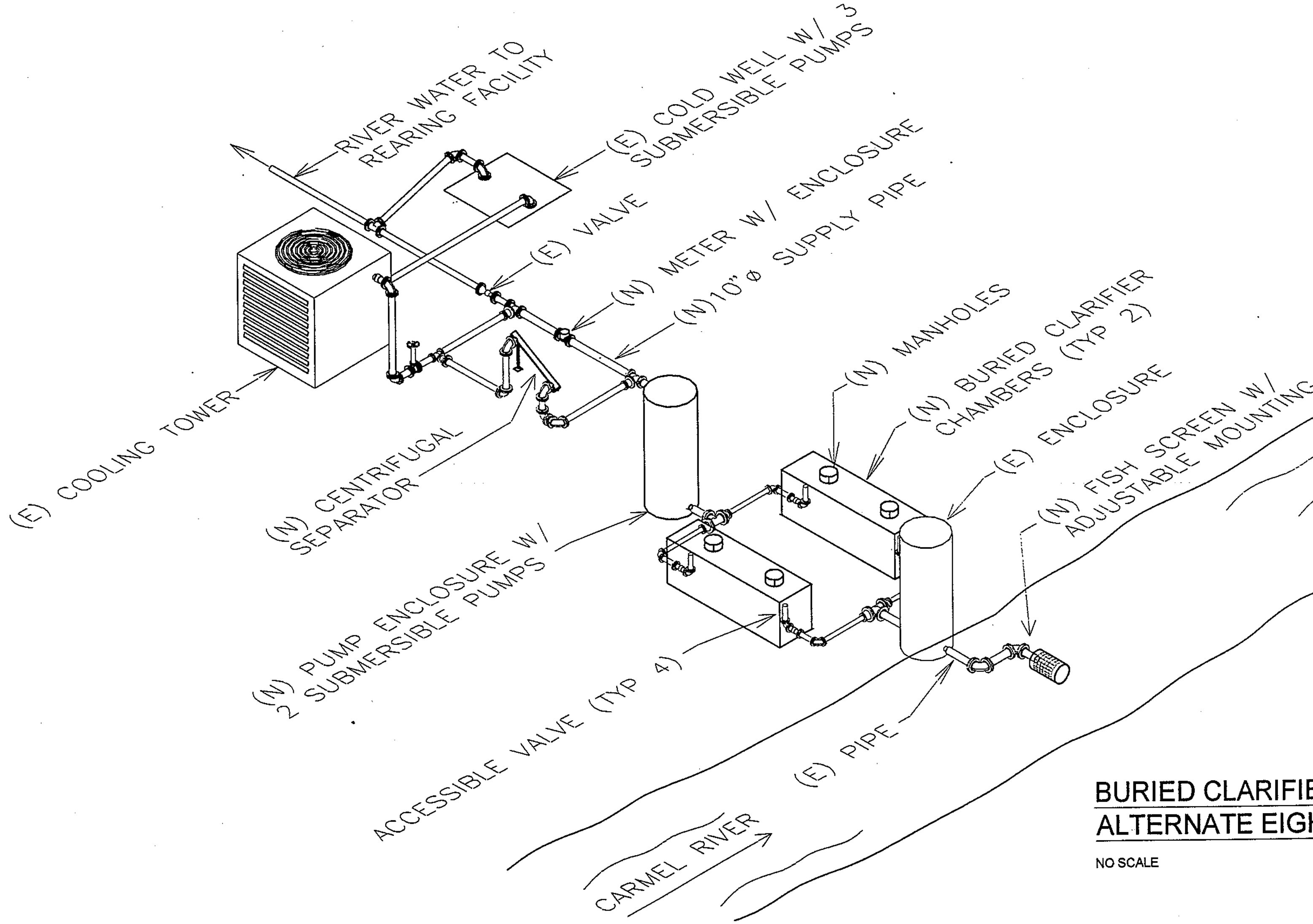


BURIED CLARIFIERS
ALTERNATE EIGHT

NO SCALE

192

Ron Blue

From: Dave Dettman [Dave@mpwmd.dst.ca.us]
Sent: Tuesday, February 04, 2003 2:04 PM
To: Ron Blue
Cc: Joe Oliver
Subject: Sleepy Hollow Drawdown test results

Ron: The results for the drawdown test are as follows:
Let me know how this affects feasibility of intake array.
Dave

Transmissivity = 264 (20gpm)/1.792 = 2,946 gpd/ft

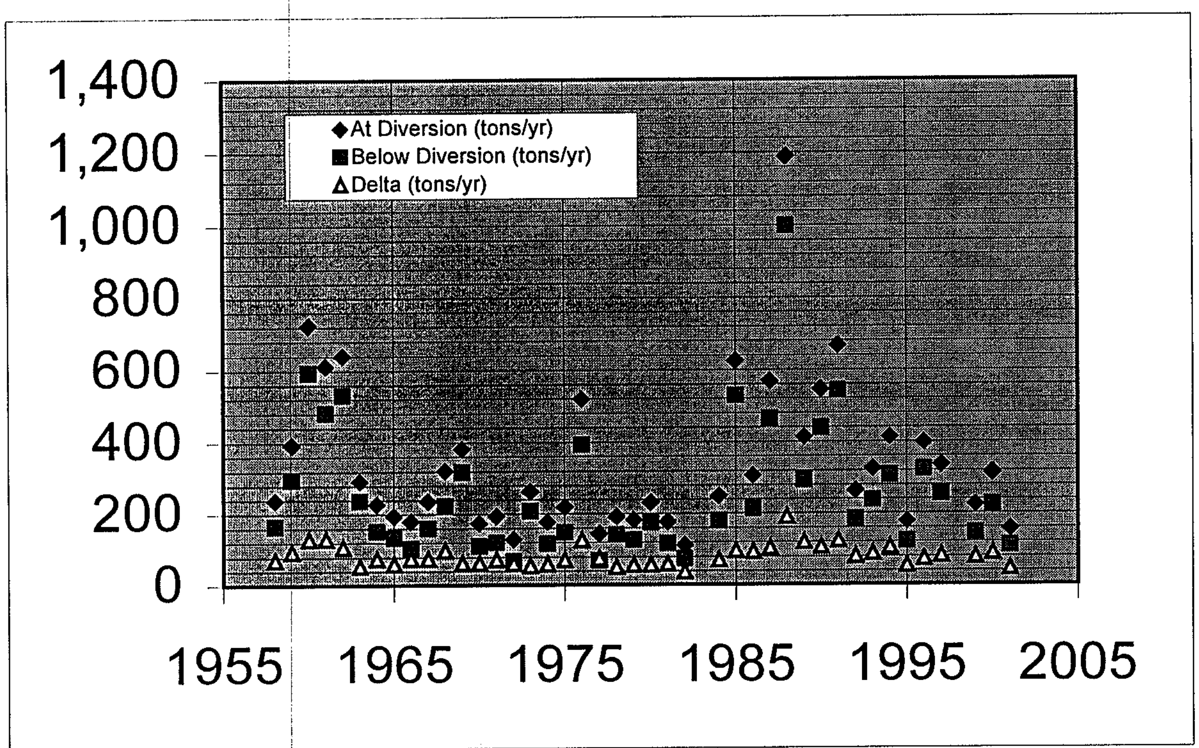
Hydraulic Conductivity = T/D = 2,946/25 = 118 gpd/ft^2

Range, given possible error in Q: 118 - 236 gpd/ft^2

APPENDIX C

Summary: Probable Quantity of Bedload Transported at Intake to Sleepy Hollow, Baseline levels.
Based on bedload transport rate from Mussetter (2002) and baseline contribution of sediment from watershed upstream of San Clemente Dam.

Year	At Diversion (tons/yr)	Below Diversion (tons/yr)	Delta (tons/yr)
1958	238.46	166.25	72.22
1959	392.63	297.40	95.23
1960	724.46	594.27	130.19
1961	612.15	481.36	130.79
1962	639.65	531.71	107.95
1963	292.20	237.68	54.52
1964	227.36	151.61	75.75
1965	194.52	133.70	60.83
1966	179.69	104.30	75.38
1967	236.44	160.81	75.63
1968	321.76	223.51	98.25
1969	381.28	318.43	62.85
1970	173.77	110.44	63.33
1971	193.63	120.30	73.33
1972	130.14	68.59	61.55
1973	262.83	207.34	55.49
1974	176.68	116.77	59.91
1975	219.01	147.39	71.62
1976	519.48	393.28	126.21
1977	144.69	69.11	75.58
1978	191.93	141.18	50.75
1979	182.95	126.16	56.79
1980	230.80	173.76	57.04
1981	177.71	117.05	60.67
1982	112.03	74.66	37.37
1983			
1984	249.88	179.11	70.77
1985	625.22	528.42	96.80
1986	307.10	212.93	94.17
1987	568.77	464.19	104.59

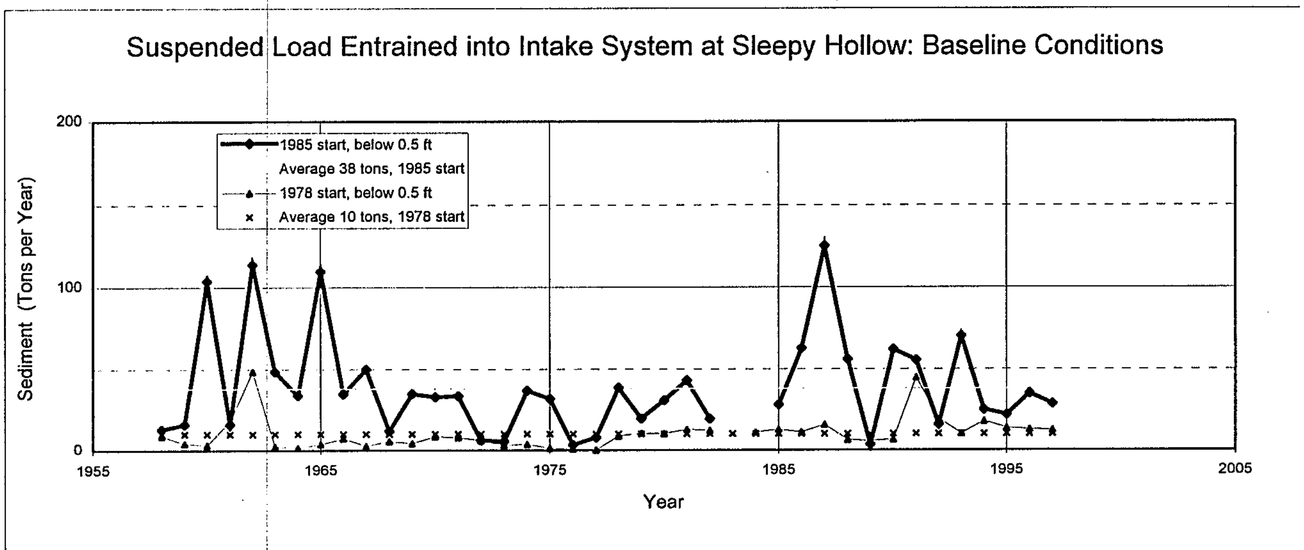


APPENDIX D

1988	1189.34	998.61	190.73
1989	413.40	293.15	120.25
1990	545.96	438.44	107.52
1991	667.86	542.64	125.22
1992	264.67	184.23	80.43
1993	326.05	236.86	89.18
1994	413.39	308.03	105.36
1995	177.56	122.49	55.07
1996	397.47	323.28	74.19
1997	336.12	253.91	82.22
1998			
1999	224.55	145.07	79.48
2000	314.85	225.07	89.79
2001	156.30	109.61	46.69
		Average	83.37
		Maximum	190.73
		Minimum	37.37

Summary: Probable Quantity of Suspended Load in 2cfs diversion at Sleepy Hollow, Baseline levels.
Based on estimated concentration of suspended load from Mussetter (2002) and baseline contribution of sediment from watershed upstream of San Clemente Dam.

Year	1985 start, below 0.5 ft	Average 38 tons, 1985 start	1978 start, below 0.5 ft	Average 10 tons, 1978 start
1958	12.85	38.00	8.74	10.00
1959	15.88	38.00	4.09	10.00
1960	103.69	38.00	3.16	10.00
1961	15.86	38.00	17.91	10.00
1962	113.94	38.00	48.50	10.00
1963	48.35	38.00	2.37	10.00
1964	33.81	38.00	1.31	10.00
1965	109.61	38.00	3.46	10.00
1966	34.70	38.00	7.24	10.00
1967	49.96	38.00	2.44	10.00
1968	11.79	38.00	5.50	10.00
1969	34.81	38.00	4.06	10.00
1970	32.72	38.00	8.38	10.00
1971	33.35	38.00	7.73	10.00
1972	6.05	38.00	5.90	10.00
1973	5.24	38.00	2.98	10.00
1974	36.63	38.00	3.49	10.00
1975	31.56	38.00	1.20	10.00
1976	3.18	38.00	0.62	10.00
1977	7.74	38.00	0.00	10.00
1978	38.51	38.00	8.45	10.00
1979	19.45	38.00	10.36	10.00
1980	30.74	38.00	10.12	10.00
1981	42.93	38.00	12.67	10.00
1982	19.25	38.00	12.03	10.00
1983		38.00		10.00
1984		38.00	10.87	10.00
1985	27.89	38.00	12.67	10.00
1986	62.68	38.00	10.92	10.00
1987	125.17	38.00	15.60	10.00
1988	55.91	38.00	6.29	10.00
1989	3.24	38.00	5.47	10.00
1990	61.89	38.00	6.48	10.00
1991	55.35	38.00	44.72	10.00
1992	15.63	38.00	19.16	10.00
1993	70.39	38.00	10.00	10.00
1994	24.78	38.00	17.67	10.00
1995	21.75	38.00	13.54	10.00
1996	35.00	38.00	12.60	10.00
1997	28.52	38.00	12.14	10.00
1998				
1999				
2000				
2001				
Average	38.97		10.02	
Maximum	125.17		48.50	
Minimum	3.18		0.00	



APPENDIX E

Minimum Overflow Rates and Basin Areas Various Particle Sizes

Particle Diam (mm)	Desc.	Stokes Law Settling Velocity (cm/s)	Stokes Law Settling Velocity (ft/s)	Overflow Rate (g/day/ft^2)	Required Effective Basin Area (ft^2)	Minimum Design Basin Size (ft^2)
0.83	Grit (Coarse Sand) [20 Mesh]	47.26	1.55	1,002,059	1	3
0.21	Grit (Med Sand) [65 Mesh]	3.03	0.10	64,147	20	40
0.15	Grit (Fine Sand) [100 Mesh]	1.54	0.05	32,728	40	79
0.062	Very Fine Sand	0.26	0.01	5,591	232	464
0.05	Silt (Very Coarse)	0.17	0.01	3,636.4	356	713
0.02	Silt (Coarse)	0.03	0.00	581.8	2,227	4,455
0.012	Silt (Medium)	0.01	0.00	209.46	6,187	12,375
0.006	Silt (Fine)	0.00	0.00	52.36	24,749	49,499
0.003	Silt (Very Fine)	0.00	0.00	13.09	98,998	197,996
<0.02	Clay	n/a	n/a	n/a	n/a	n/a

Input Assumptions:

Constant Flow (gpm) =	900	
Basin Efficiency=	50%	
Stokes Law Settling, Vs=	$g(r_s\text{-}r)d^2/18u$	
Abs. Viscosity H_20 @ 10°C, u=	0.013097	gm/cm-sec
Sand Particle Density, r_s=	2.65	gm/cm^3
Density H_20 @ 10°C, r=	0.99973	gm/cm^3
Acc. Gravity, g=	980	cm/sec^2
Velocity:Overflow Rate,1 ft/sec=	646,272	$gal/day/ft^2$

APPENDIX F