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EPA Superfund
Record of Decision:

COAST WOOD PRESERVING
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UKIAH, CA
09/29/1989

COAST WOOD PRESERVING, INC.
UKIAH, CALIFORNIA

#SBP
STATEMENT OF BASIS AND PURPOSE:

THIS DOCUMENT SERVES AS EPA SELECTION OF THE REMEDIAL ACTION FOR THE COAST WOOD PRESERVING, INC. SITE. THE CALIFORNIA DEPARTMENT OF HEALTH SERVICES, TOXIC SUBSTANCES CONTROL DIVISION, REGION 2, (CDHS) HAS APPROVED THIS REMEDIAL ACTION IN CONFORMANCE WITH: SECTION 13000 AND 13304 OF THE CALIFORNIA WATER CODE, STATE OF CALIFORNIA HEALTH AND SAFETY CODE SECTION 25356.1, THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA) AND THE NATIONAL CONTINGENCY PLAN.

THIS EPA SELECTION OF REMEDY IS BASED UPON THE CDHS REMEDIAL ACTION PLAN, THE RESPONSIVENESS SUMMARY, THE REMEDIAL INVESTIGATION, THE FEASIBILITY STUDY, AND THE ADMINISTRATIVE RECORD FOR THIS SITE. THE ATTACHED INDEX LISTS THE ITEMS COMPRISING THE ADMINISTRATIVE RECORD.

DESCRIPTION OF REMEDIAL ACTION

THE SELECTED REMEDY PROVIDES FOR FINAL CLEAN-UP REQUIREMENTS RELATED TO ONSITE SOILS AND GROUNDWATER AND THE PREVENTION OF OFFSITE MIGRATION OF CONTAMINANTS. IN ADDITION, A CONTINGENCY IS PROVIDED FOR THE REMEDIATION OF OFFSITE GROUNDWATER IN THE EVENT THAT CHROMIUM LEVELS RISE OVER ACCEPTABLE LEVELS.

OVER THE YEARS, A NUMBER OF REMEDIAL MEASURES HAVE BEEN UNDERTAKEN BY COAST WOOD PRESERVING, INC. TO REDUCE THE MIGRATION OF CHROMIUM, COPPER AND ARSENIC CONTAMINATION AND TO BEGIN GROUNDWATER REMEDIATION. THESE MEASURES INCLUDED CONSTRUCTING SURFACE WATER RUN-OFF BERMS, PAVING OVER EXPOSED SOIL ZONES, AND CONSTRUCTING ROOFS OVER THE RETORT AREAS TO REDUCE THE POTENTIAL FOR ADDITIONAL SOIL, STORM WATER AND GROUNDWATER CONTAMINATION. IN 1983, WITHOUT REGULATORY AGENCY APPROVAL, COAST WOOD PRESERVING CONSTRUCTED A 300-FOOT SLURRY CUTOFF WALL ALONG THE EASTERN BOUNDARY OF THE SITE. A GROUNDWATER EXTRACTION TRENCH WAS INSTALLED ON THE UPGRADIENT SIDE OF THE SLURRY WALL. EXTRACTED GROUNDWATER IS PIPED TO AN ON-SITE ELECTROCHEMICAL TREATMENT FACILITY PRIOR TO REUSE, REINJECTION OR DISCHARGE. THE SLURRY WALL AND EXTRACTION WELL HAVE BEEN EFFECTIVE IN REDUCING FURTHER OFF-SITE MIGRATION OF HEAVY METALS.

UNDER AGREEMENT WITH THE STATE OF CALIFORNIA, COAST WOOD PRESERVING WILL BE RESPONSIBLE FOR THE REMEDIATION OF CONTAMINATED SOILS AT THE TIME OF CLOSURE OF THE FACILITY PROJECTED TO BE IN TEN (10) YEARS. A TRUST FUND WILL BE ESTABLISHED WITH ANNUAL PAYMENTS TO BE MADE BY COAST WOOD PRESERVING, INC. TO FUND THIS PORTION OF THE SITE REMEDIATION. TREATABILITY STUDIES WILL BE CONDUCTED PRIOR TO CDHS AND EPA SELECTION OF THE MOST EFFECTIVE AND COST EFFICIENT TECHNOLOGY.

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DECLARATION

EPA UNDER CERCLA, HAS SELECTED THIS GROUNDWATER REMEDY FOR THE COAST WOOD PRESERVING, INC. SITE. THE REMEDY IS PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT, ATTAINS FEDERAL AND STATE REQUIREMENTS THAT ARE APPLICABLE OR RELEVANT AND APPROPRIATE TO THE REMEDIAL ACTION, AND IS COST- AND TIME EFFECTIVE. THIS REMEDY SATISFIES FEDERAL STATUTORY PREFERENCES FOR REMEDIES THAT REDUCE TOXICITY, MOBILITY, OR VOLUME OF CONTAMINANTS AS A PRINCIPAL ELEMENT. IT ALSO UTILIZES PERMANENT SOLUTIONS TO THE MAXIMUM EXTENT PRACTICABLE.

AS THIS REMEDY WILL RESULT IN HAZARDOUS SUBSTANCES REMAINING ON-SITE ABOVE HEALTH BASED LEVELS, A REVIEW WILL BE CONDUCTED BY EPA EACH FIVE (5) YEARS AFTER COMMENCEMENT OF REMEDIAL ACTION TO ENSURE THE REMEDY CONTINUES TO PROVIDE ADEQUATE PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT. IF THIS SELECTED REMEDIAL ACTION DOES NOT MEET THE GOALS AND CLEANUP OBJECTIVES IDENTIFIED IN THE REMEDY, OR IS NOT SUFFICIENTLY PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT, THEN EPA MAY, UNDER THE AUTHORITIES OF CERCLA, REQUIRE ADDITIONAL RESPONSE ACTION FROM COAST WOOD PRESERVING, INC.

DATE:09/29/89 DANIEL W. MCGOVERN
REGIONAL ADMINISTRATOR

#INT

1.0 INTRODUCTION

SINCE JUNE 1980, A NUMBER OF STUDIES HAVE BEEN CONDUCTED TO INVESTIGATE THE PRESENCE OF CHROMIUM, COPPER, AND ARSENIC IN THE SUBSURFACE ENVIRONMENT AT THE COAST WOOD PRESERVING, INC. (CWP) FACILITY (THE SITE) IN UKIAH, CALIFORNIA. THE INVESTIGATIONS WERE DESIGNED TO CHARACTERIZE SURFACE AND SUBSURFACE CONDITIONS AND DELINEATE THE AREAL AND VERTICAL EXTENT OF CHROMIUM, COPPER, AND ARSENIC IN SOIL AND GROUND WATER AT THE SITE. CONCURRENT WITH THE INVESTIGATIONS, A NUMBER OF INTERIM REMEDIAL MEASURES HAVE BEEN IMPLEMENTED TO CONTAIN THE CHROMIUM PLUME IN GROUND WATER AND REMEDIATE SUBSURFACE CONDITIONS.

THE STATE AND FEDERAL AGENCIES RESPONSIBLE FOR OVERSEEING THE CWP INVESTIGATIONS INCLUDE THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, NORTH COAST REGION (RWQCB), DEPARTMENT OF HEALTH SERVICES (DHS), AND US ENVIRONMENTAL AGENCY (EPA). THROUGHOUT THIS REPORT, THE RWQCB, DHS, AND EPA ARE REFERRED TO COLLECTIVELY AS "THE REGULATORY AGENCIES."

IN COMPLIANCE WITH SECTION 25356.1 OF THE CALIFORNIA HEALTH AND SAFETY CODE (1986), THE REGULATORY AGENCIES HAVE REQUESTED THAT CWP SUBMIT A REMEDIAL ACTION PLAN (RAP) TO ADDRESS SOIL AND GROUND WATER CONTAMINATION WHICH MAY HAVE ORIGINATED FROM CWP'S OPERATION. ON BEHALF OF CWP AND IN RESPONSE TO THIS REQUEST, GEOSYSTEM CONSULTANTS, INC. (GEOSYSTEM) SUBMITTED A PREDRAFT PAP (GEOSYSTEM, SEPTEMBER IS, 1986) TO THE REGULATORY AGENCIES FOR REVIEW. SUBSEQUENT TO THE SUBMITTAL OF THE PREDRAFT RAP, A NUMBER OF ADDITIONAL INVESTIGATIONS WERE PERFORMED AT THE SITE. ALSO, IN FEBRUARY 1987, THE DHS ISSUED A DRAFT GUIDANCE DOCUMENT FOR RAP PREPARATION. THE DRAFT GUIDANCE DOCUMENT PROVIDED THE FORMAT, CONTENT, AND PROCEDURES FOR PREPARATION, APPROVAL, AND IMPLEMENTATION OF THE RAP.

UTILIZING THE 'RESULTS OF ADDITIONAL INVESTIGATIONS AND CONSIDERING THE REGULATORY AGENCIES' REVIEW COMMENTS, A DRAFT RAP WAS PREPARED BY GEOSYSTEM IN ACCORDANCE WITH THE FEBRUARY 1987 DRAFT RAP GUIDELINES. SHE DRAFT RAP WAS SUBMITTED FOR REVIEW IN JULY 1987. IN SEPTEMBER 1987, THE DHS ISSUED A DETAILED OUTLINE FOR THE PREPARATION OF RAPS ENTITLED "DHS, POLICY AND PROCEDURE FOR REMEDIAL ACTION PLAN DEVELOPMENT AND APPROVED PROCESSES" (DHS, SEPTEMBER 1987). ALSO, IN SEPTEMBER 1987, THE REGULATORY AGENCIES PROVIDED REVIEW COMMENTS ON THE DRAFT RAP SUBMITTED IN JULY 1987. THE AGENCIES' COMMENTS AND THE CONTENT AND FORMAT OF THE MOST RECENT RAP GUIDELINES (DHS, SEPTEMBER 1987) WERE CONSIDERED IN THE PREPARATION OF DRAFT NO. 2 OF THE RAP, WHICH WAS ISSUED IN FEBRUARY 1988 (GEOSYSTEM, FEBRUARY 29, 1988). SUBSEQUENTLY, ON AUGUST 4, 1988, AGENCY COMMENTS ON DRAFT NO. 2 OF THE RAP WERE RECEIVED.1 ALSO, ON DECEMBER 16, 1988, THE DHS ISSUED A REMEDIAL ACTION ORDER PROVIDING THE FRAMEWORK FOR FUTURE SITE ACTIVITIES, INCLUDING THE PREPARATION OF THE THIRD DRAFT OF THE RAP. ON FEBRUARY 3, 1989, GEOSYSTEM ISSUED THE THIRD DRAFT OF THE RAP FOR AGENCY REVIEW. AGENCY COMMENTS WERE CONSIDERED IN THE PREPARATION OF THE FINAL DRAFT RAP, WHICH WAS ISSUED ON MAY 3, 1989. ON AUGUST 1, 1989, THE DHS ISSUED A NUMBER OF COMMENTS AND CHANGES TO BE ADDRESSED IN THE FINAL RAP (DHS, AUGUST 1, 1989).

IT IS NOTED THAT THE RAP GUIDELINES PREPARED BY THE DHS ARE CONSISTENT WITH SECTION 25350, SUBPART F OF THE NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN (US EPA, JULY 1985), SECTION 25356.1 OF THE CALIFORNIA HEALTH AND SAFETY CODE (1986), AND THE CALIFORNIA SITE MITIGATION DECISION TREE (DHS, JUNE 1985).

1.1 OBJECTIVE

ACCORDING TO THE SEPTEMBER 1987 DHS GUIDELINES FOR RAP PREPARATION, THE PURPOSE OF A RAP IS TO COMPILE AND SUMMARIZE SITE DATA GATHERED FROM THE REMEDIAL INVESTIGATION (RI) AND THE FEASIBILITY STUDY (FS), IN ORDER TO IDENTIFY, AND SUBSEQUENTLY DESIGN, PLAN AND IMPLEMENT A FINAL REMEDIAL ACTION FOR A HAZARDOUS SUBSTANCE RELEASE SITE." THE SPECIFIC OBJECTIVE OF THIS RAP IS TO PRESENT THE FINDINGS OF THE INVESTIGATIONS PERFORMED AT THE CUP SITE, THE RATIONALE FOR SELECTION OR REJECTION OF THE REMEDIAL ALTERNATIVES CONSIDERED, AND THE TIMEFRAME FOR REMEDIAL ACTION IMPLEMENTATION. THE RAP IS INTENDED TO PROVIDE AN OPPORTUNITY FOR THE PUBLIC AND OTHER INTERESTED PARTIES TO PARTICIPATE IN THE REMEDIAL ACTION DECISION-MAKING PROCESS. ACCORDING TO THE DHS, IF THE REMEDIAL ACTION PLAN IS FULLY IMPLEMENTED AND COMPLETED, "THE SITE WILL BE CERTIFIED AND TRANSFERRED TO A LIST OF SITES WHICH REQUIRE LONG TERM OPERATION AND MAINTENANCE."

1.2 SITE IDENTIFICATION

THE SITE IS KNOWN AS THE COAST WOOD PRESERVING, INC. (CUP) FACILITY AND IS LOCATED THREE MILES SOUTH OF UKIAH, CALIFORNIA, AT THE INTERSECTION OF HIGHWAY 101 AND TAYLOR DRIVE. THE SITE LOCATION IS SHOWN IN FIGURE 1. CWP HAS CONDUCTED WOOD PRESERVING OPERATIONS AT THE SITE SINCE 1971 AND THE FACILITY IS CURRENTLY ACTIVE. ADDITIONAL DETAILS OF CUP'S WOOD PRESERVING OPERATION ARE PRESENTED IN SECTION 3.2.1.

1.3 SCOPE AND REPORT ORGANIZATION

THE RAP INCLUDES RELEVANT BACKGROUND INFORMATION, A SUMMARY AND INTERPRETATION OF THE HYDROGEOLOGIC DATA, A SUMMARY OF SOIL AND GROUND WATER QUALITY DATA, A DESCRIPTION OF THE INTERIM REMEDIAL MEASURES IMPLEMENTED, A RISK ASSESSMENT, AND AN EVALUATION OF REMEDIAL ACTION ALTERNATIVES, IN ADDITION, THE RATIONALE FOR SELECTION OF THE PROPOSED REMEDIAL ACTIONS AND REJECTION OF HE OTHERS IS PRESENTED.

THE FORMAT AND ORGANIZATION OF THIS DOCUMENT ARE CONSISTENT WITH THE RAP GUIDELINES (DHS, SEPTEMBER 1987). AN EXECUTIVE SUMMARY, INCLUDING A BRIEF DESCRIPTION OF SIGNIFICANT FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS, IS PROVIDED IN SECTION 2.0. SECTION 3.0 PRESENTS A SITE DESCRIPTION, INCLUDING THE HISTORY OF WOOD PRESERVING OPERATIONS AND THE PHYSICAL CHARACTERISTICS OF THE SITE. SECTION 4.0 CONTAINS A SUMMARY OF THE GEOLOGIC, HYDROLOGIC, AND CHEMICAL CHARACTERISTICS OF SOIL, SURFACE WATER, AND GROUND WATER AT THE SITE AND IMMEDIATE VICINITY BASED ON THE REMEDIAL INVESTIGATIONS PERFORMED. SECTION 5.0 DESCRIBES THE INTERIM REMEDIAL MEASURES IMPLEMENTED DURING THE COURSE OF THE INVESTIGATIONS AT THE SITE. SECTION 6.0 SUMMARIZES POTENTIAL MIGRATION PATHWAYS AND CHROMIUM TOXICITY, AND EVALUATES THE POSSIBLE EXPOSURE OF THE CONTAMINANTS' TO POTENTIAL RECEPTORS.

SECTION 7.0 PRESENTS THE REMEDIAL ACTION ALTERNATIVES CONSIDERED TO ADDRESS SOIL AND GROUND WATER CONTAMINATION, INCLUDING ALTERNATIVE METHODS OF GROUND WATER TREATMENT AND DISCHARGE. IN ADDITION, THE RECOMMENDED REMEDIAL ACTION TO ADDRESS SOIL AND GROUNDWATER CONTAMINATION IS PRESENTED IN SECTION 7.0. THE RATIONALE FOR THE SELECTION OF THE PROPOSED REMEDIAL PLAN AND THE APPLICABLE REGULATIONS ARE ALSO PRESENTED IN THIS SECTION.

THE SCHEDULE FOR IMPLEMENTATION OF THE RAP IS PRESENTED IN SECTION 8.0. THE ALLOCATION OF FINANCIAL RESPONSIBILITY AND PROVISIONS FOR FINANCIAL ASSURANCE ARE PRESENTED IN SECTION 9.0. THE OPERATION AND MAINTENANCE REQUIREMENTS ARE DESCRIBED IN SECTION 10.0.

2.0 EXECUTIVE SUMMARY

THE REMEDIAL ACTION PLAN (RAP) PRESENTS THE RATIONALE, APPROACH, AND FRAMEWORK FOR THE PROPOSED REMEDIATION PROGRAM AT THE COAST WOOD PRESERVING, INC. (CWP) FACILITY IN UKIAH, CALIFORNIA.

2.1 APPLICABLE LAWS AND REGULATIONS

THE RAP HAS BEEN PREPARED IN ACCORDANCE WITH THE GUIDANCE DOCUMENT ENTITLED "REMEDIAL ACTION PLAN DEVELOPMENT AND APPROVAL PROCESS," ISSUED BY THE DHS (SEPTEMBER 1987). THE RAP IS ALSO CONSISTENT WITH THE FOLLOWING STATE AND FEDERAL REQUIREMENTS AND GUIDELINES:

- COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA) OF 1980, AS AMENDED BY THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) OF 1986.
- RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) OF 1976, AS AMENDED BY THE HAZARDOUS AND SOLID WASTE AMENDMENTS (HSWA) OF 1984.
- SAFE DRINKING WATER ACT.
- CALIFORNIA CODE OF REGULATIONS, TITLE 22, DIVISION 4: ENVIRONMENTAL HEALTH (CHAPTER 1, ARTICLE 1; CHAPTER 2, ARTICLE 1; CHAPTER 30), JULY 1986.
- CALIFORNIA HEALTH AND SAFETY CODE.
- NORTH COASTAL BASIN WATER QUALITY CONTROL PLAN ADOPTED BY THE RWQCS.
- ALL ORDERS, INCLUDING SPECIFICATIONS, PROVISIONS, PROHIBITIONS, AND REQUIREMENTS ISSUED BY THE RWQCB.

- COURT ORDER BY THE STATE OF CALIFORNIA, OFFICE OF THE ATTORNEY GENERAL.
- NATIONAL CONTINGENCY PLAN, PERTINENT HAZARDOUS WASTE REGULATIONS UNDER 40 CFR, PARTS 260 TO 265; PART 300-68, JULY 1985.
- PORTER-COLOGNE WATER QUALITY CONTROL ACT, 1969.

2.2 BACKGROUND

SINCE 1980, A NUMBER OF INVESTIGATIONS HAVE BEEN PERFORMED TO DELINEATE THE AREAL AND VERTICAL EXTENT OF CHROMIUM IN SOIL AND GROUND WATER AT THE CWP SITE AND TO CHARACTERIZE HYDROGEOLOGIC CONDITIONS. SOIL QUALITY INVESTIGATIONS HAVE SHOWN THAT ELEVATED CHROMIUM AND ARSENIC CONCENTRATIONS EXIST IN THE UPPER 1 TO 2 FEED OF THE SOIL PROFILE NEAR AND AROUND THE RETORT AREA. MOST SOIL SAMPLES ANALYZED FOR TOTAL CHROMIUM AND HEXAVALENT CHROMIUM HAVE INDICATED THAT TRIVALENT CHROMIUM COMPOUNDS ARE PREVALENT IN THE NEAR-SURFACE SOILS.

HYDROGEOLOGIC STUDIES HAVE DEMONSTRATED THAT THE SITE IS UNDERLAIN BY FOUR HYDROSTRATIGRAPHIC ZONES. THE UPPER ZONE (ZONE 1) CONSISTS OF SILTY CLAY AND CLAYEY SILT, WITH MORE PERMEABLE STRINGERS AND LENSES OF SAND AND GRAVEL, TO A DEPTH OF ABOUT 20 FEET. THIS ZONE IS SEPARATED FROM A MORE PERMEABLE SAND AND GRAVEL LAYER (ZONE 2) BY A BLUE CLAY. ZONE 3 IS A CLAYEY SILT STRATUM, AND ZONE 4 CONSISTS OF CLAYEY SAND AND GRAVEL. ZONE 1 IS THE PRIMARY ZONE OF CONCERN BECAUSE OF THE PRESENCE OF CHROMIUM IN GROUND WATER. THE DEPTH TO GROUND WATER VARIES FROM 5 TO 10 FEET AND GROUND WATER GENERALLY FLOWS TO THE SOUTHEAST.

GROUND WATER QUALITY DATA SHOW THAT CHROMIUM CONCENTRATIONS ARE HIGHER NEAR THE RETORT AREA AND DECREASE IN THE DOWNGRADIENT DIRECTION. IN THE LAST THREE YEARS, MOST OFF-SITE WELLS HAVE NOT EXHIBITED CHROMIUM CONCENTRATIONS IN EXCESS OF THE DRINKING WATER STANDARD (0.05 MG/L). MOST STORM WATER QUALITY MONITORING DATA INDICATE THAT CHROMIUM CONCENTRATIONS ARE GENERALLY NEAR OR BELOW DETECTION LIMITS.

GEOCHEMICAL TESTS HAVE BEEN PERFORMED TO EVALUATE THE SORPTION AND DESORPTION CHARACTERISTICS OF CHROMIUM AND ARSENIC IN SOIL AND GROUND WATER. SORPTION TESTS HAVE SHOWN THAT ZONE 1 MATERIAL IS CAPABLE OF ADSORBING HEXAVALENT CHROMIUM TO THE EXTENT THAT CHROMIUM MIGRATION IS AT LEAST 5 TIMES SLOWER THAN GROUND WATER FLOW. DESORPTION TESTS HAVE INDICATED THAT A REDUCTION IN CHROMIUM CONCENTRATION CAN BE ACHIEVED BY GROUND WATER EXTRACTION. THE GEOCHEMICAL DATA HAVE BEEN USED TO ESTIMATE THE TIME OF AQUIFER CLEANUP. THE ABSENCE OF DISSOLVED ARSENIC IN GROUND WATER MONITORING WELLS INDICATES HIGH ADSORPTION CAPACITY FOR ARSENIC COMPOUNDS.

POTENTIAL MIGRATION PATHWAYS THROUGH AIR, DIRECT EXPOSURE TO SOIL, SURFACE WATER, AND GROUND WATER HAVE BEEN ASSESSED. IT IS CONCLUDED THAT THE MOST PROBABLE MIGRATION PATHWAY IS VIA GROUND WATER FLOW. BECAUSE OF THE OVERALL SITE IMPROVEMENTS AND THE INTERIM REMEDIAL MEASURES IMPLEMENTED, HOWEVER, OFF-SITE MIGRATION IS UNLIKELY A TRANSPORT MODEL HAS BEEN UTILIZED TO ASSESS THE AREAL DISTRIBUTION OF CHROMIUM IN CASE OF OFF-SITE MIGRATION. CONSIDERING THE LOW POPULATION DENSITY DOWNGRADIENT OF THE FACILITY AND THE ABSENCE OF WATER-PRODUCING WELLS IN THE IMMEDIATE SITE VICINITY, THERE IS NO PRESENT POTENTIAL EXPOSURE THROUGH GROUND WATER. THEREFORE, THERE IS NO HEALTH RISK ASSOCIATED WITH THIS PATHWAY IF OFF-SITE MIGRATION IS PREVENTED.

2.3 INTERIM REMEDIAL MEASURES

SINCE THE INITIATION OF INVESTIGATIONS AT THE CWP SITE, A NUMBER OF REMEDIAL MEASURES HAVE BEEN IMPLEMENTED BY CWP. GENERAL FACILITY IMPROVEMENTS HAVE INCLUDED GRADING AND CONSTRUCTION OF BERMS TO PREVENT SURFACE RUNOFF FROM THE RETORT AND TREATED WOOD STORAGE AREA. SURFACE PAVING, AND CONSTRUCTION OF ROOFS OVER THE RETORT AREA. THESE IMPROVEMENTS HAVE SUBSTANTIALLY REDUCED THE POTENTIAL FOR SOIL, STORM WATER, AND GROUND WATER CONTAMINATION.

IN OCTOBER 1983, WITHOUT REGULATORY AGENCY APPROVAL AND/OR OVERSIGHT, CWP CONSTRUCTED A 300-FOOT LONG, SLURRY CUTOFF WALL ALONG THE EASTERN SITE BOUNDARY TO A DEPTH OF ABOUT 20 FEET. CHROMIUM-CONTAINING GROUND WATER IS PUMPED FROM AN EXTRACTION TRENCH LOCATED HYDRAULICALLY UPGRADIENT OF THE SLURRY WALL. THE TRENCH APPEARS TO BE CAPABLE OF INTERCEPTING AND HYDRAULICALLY CONTROLLING GROUND WATER IN ZONE 1. EXTRACTED WATER IS RECYCLED BACK INTO CWP OPERATIONS WHEN POSSIBLE. THE PRESENCE OF THE SLURRY CUTOFF WALL AND EXTRACTION FROM THE TRENCH HAVE BEEN EFFECTIVE IN REDUCING THE OFF SITE MIGRATION OF CHROMIUM.

2.4 REMEDIAL ACTION ALTERNATIVES

A FEASIBILITY STUDY HAS BEEN CONDUCTED TO SCREEN AND EVALUATE VIABLE REMEDIAL ACTION ALTERNATIVES. IN CONDUCTING THE FEASIBILITY STUDY, CONTAMINATED SOIL WAS CONSIDERED THE PRIMARY POTENTIAL SOURCE OF GROUND WATER CONTAMINATION. CONTAMINATED GROUND WATER WAS CONSIDERED THE PRINCIPAL POTENTIAL HAZARD TO HUMAN HEALTH AND THE ENVIRONMENT. IN EVALUATING THE ALTERNATIVES, SOIL AND GROUND WATER ELEMENTS WERE ADDRESSED SEPARATELY.

REMEDIATION OF CONTAMINATED SOILS WILL OCCUR AT THE TIME OF CLOSURE OF THE FACILITY, PROJECTED TO BE 30 YEARS. A TRUST FUND WILL BE ESTABLISHED (SECTION 9.0) TO FUND FUTURE REMEDIATION OF SOILS. THE POTENTIAL REMEDIAL OPTIONS CONSIDERED FOR CONTROL OF THE CONTAMINATED SOIL INCLUDED SOIL REMOVAL/OFF-SITE DISPOSAL, SOIL REMOVAL/ON-SITE TREATMENT, CONTAINMENT, IN-SITU TREATMENT, AND NO ACTION. TREATABILITY STUDIES WILL BE CONDUCTED PRIOR TO SELECTING THE FINAL SOILS REMEDY AT THE TIME OF CLOSURE OF THE FACILITY. IT IS ANTICIPATED THAT ON-SITE SOIL TREATMENT OPTIONS WILL INCREASE AS THIS TECHNOLOGY DEVELOPS OVER THE NEXT 5 TO 10 YEARS.

THE ALTERNATIVES CONSIDERED FOR CONTROL OF THE CHROMIUM PLUME INCLUDED PHYSICAL CONTAINMENT, IN-SITU TREATMENT, HYDRAULIC CONTROL, AND NO ACTION. BASED ON PROVEN TECHNOLOGICAL CONSIDERATIONS AND COST, HYDRAULIC CONTROL WAS SELECTED AS THE MOST COST-EFFECTIVE REMEDIAL MEASURE. THIS OPTION WAS EVALUATED FOR PLUME CONTROL NEAR THE RETORT AREA, NEAR THE SITE BOUNDARY, AND OFF SITE.

AS HYDRAULIC CONTROL REQUIRES PROPER HANDLING OF CONTAMINATED GROUND WATER, VARIOUS DISCHARGE OPTIONS WERE CONSIDERED. THE MOST COST-EFFECTIVE OPTIONS INCLUDE RECYCLING THE GROUND WATER INTO CWP OPERATIONS OR DISCHARGE OF TREATED WATER INTO THE SANITARY SEWER, VIABLE GROUND WATER TREATMENT OPTIONS INCLUDE ELECTROCHEMICAL PROCESSES, CHEMICAL REDUCTION/PRECIPITATION, ACTIVATED CARBON ADSORPTION, ION EXCHANGE, REVERSE OSMOSIS, AND ELECTRODIALYSIS. BASED ON AVAILABILITY, PROVEN TECHNOLOGICAL CONSIDERATIONS, AND COST-EFFECTIVENESS, THE ELECTROCHEMICAL PROCESS WAS SELECTED FOR GROUND WATER TREATMENT.

2.5 SELECTED REMEDIAL ACTION ALTERNATIVE

THE SELECTED REMEDIAL ACTION ALTERNATIVE INCLUDED THE FOLLOWING ELEMENTS:

- SURFACE RUNOFF MANAGEMENT.
- CONTROL AND REMEDIATION OF CONTAMINATED SOIL.
- PLUME CONTROL AND AQUIFER REMEDIATION.
- ELECTROCHEMICAL TREATMENT OF GROUND WATER.
- WATER RECYCLING/DISCHARGE TO UKIAH SEWAGE TREATMENT PLANT OR REINJECTION.
- MONITORING.

SURFACE RUNOFF WILL BE CONTROLLED TO PREVENT POTENTIALLY CONTAMINATED WATER ENTERING SURFACE WATER DRAINAGE FEATURES. THE SITE WILL BE INSPECTED PERIODICALLY AND SURFACE PAVING REPAIRED AS APPROPRIATE. STORM WATER MONITORING SHALL BE PERFORMED AND THE DATA EVALUATED ACCORDING TO RWQCB ORDER NO. 85-103.

CONTAMINATED SOILS WILL BE CONTROLLED BY PREVENTING SURFACE WATER INFILTRATION AND BY EXERCISING HYDRAULIC CONTROL OF THE PLUME. SURFACE PAVING WILL PREVENT THE SURFACE SOILS FROM ACTING AS A SOURCE OF GROUND WATER CONTAMINATION. CHROMIUM LEACHED FROM THE SOIL AS A RESULT OF GROUND WATER LEVEL FLUCTUATIONS WILL BE CONTROLLED HYDRAULICALLY IN THE RETORT AREA AND NEAR THE SITE BOUNDARY. HYDRAULIC CONTAINMENT WILL BE ACHIEVED BY A GROUND WATER EXTRACTION AND TREATMENT SYSTEM UTILIZING EXISTING EXTRACTION WELLS HL-7 AND CWP-18. THESE PROVISIONS WILL PREVENT DIRECT HUMAN EXPOSURE TO CONTAMINATED SOIL, ELIMINATE THE CONTRIBUTION OF INFILTRATING SURFACE WATER TO GROUND WATER CONTAMINATION, AND PREVENT OFF-SITE MIGRATION. AFTER SITE CLOSURE, THE CONTAMINATED SOILS WILL BE REMEDIATED BY ON-SITE TREATMENT, AS DISCUSSED IN THE PREVIOUS SECTION.

PLUME CONTROL AND AQUIFER REMEDIATION WILL BE PERFORMED BY GROUND WATER EXTRACTION NEAR THE

RETORT AREA AND AT THE SITE BOUNDARY. WELL CWP-18, LOCATED IN THE RETORT AREA, WILL BE PUMPED TO EXTRACT GROUND WATER CONTAINING ELEVATED CHROMIUM CONCENTRATIONS. ALTHOUGH THE YIELD OF THIS WELL IS SMALL AND CONTINUOUS PUMPING MAY NOT BE POSSIBLE, THE POTENTIAL IMPACT ON AQUIFER RESTORATION IS BELIEVED TO BE SIGNIFICANT.

AT THE SITE BOUNDARY, WELL HL-7 (INSTALLED IN THE EXTRACTION TRENCH) WILL BE PUMPED AT FLOW RATES RANGING FROM 5 TO 20 GPM. EXTRACTION FROM THE TRENCH WILL PRODUCE A ZONE OF INFLUENCE WHICH WILL CONTAIN THE CHROMIUM PLUME, PREVENT OFF-SITE MIGRATION, AND GRADUALLY RESTORE THE AQUIFER. CONSIDERING THE TOTAL ESTIMATED VOLUME OF CONTAMINATED FLUID, PORE VOLUME REDUCTION REQUIREMENTS, AND EXPECTED FLOW RATES, THE PROJECTED MINIMUM DURATION OF AQUIFER CLEANUP IS ABOUT SEVEN YEARS. HOWEVER, CONSIDERING THE NATURE OF THE ASSUMPTIONS AND UNCERTAINTIES ASSOCIATED WITH THIS ESTIMATED TIME OF AQUIFER CLEANUP, A CONSERVATIVE DURATION OF 20 YEARS IS PROJECTED FOR PROJECT MANAGEMENT AND BUDGETARY PURPOSES. PROVISION IS ALSO MADE TO EXTRACT WATER FROM WELL CWP-8, LOCATED ON THE DOWNGRADIENT SIDE OF THE SLURRY CUTOFF WALL. EXTRACTION FROM THIS WELL WILL CONTAIN ANY RESIDUAL CHROMIUM THAT MAY PASS THE BARRIER. CONTAINMENT OF CHROMIUM IN THIS LOCATION WILL PREVENT CONTAMINATION OF DOWNGRADIENT AREAS.

A CONTINGENCY PLAN HAS ALSO BEEN DEVELOPED FOR THE EXTRACTION OF GROUND WATER IN THE OFF-SITE AREA LOCATED NEAR MONITORING WELL AT-2. DEPENDING ON FUTURE CONCENTRATIONS DETECTED IN THE OFF-SITE WELLS, ADDITIONAL EXTRACTION WELLS MAY BE NECESSARY TO ENSURE HYDRAULIC CONTROL OF THE CONTAMINATED PLUME.

THE EXTRACTED WATER WILL BE RECYCLED INTO CWP OPERATIONS, TO THE EXTENT POSSIBLE, OR TREATED ELECTROCHEMICALLY AND DISCHARGED INTO THE SANITARY SEWER. IMPLEMENTATION OF THIS DISCHARGE OPTION WILL PROVIDE MAXIMUM FLEXIBILITY IN SELECTING EXTRACTION RATES FROM WELL HL-7, AND WILL INCREASE THE EFFECTIVENESS OF CLEANUP OPERATIONS. THE TREATMENT SYSTEM EFFLUENT CONCENTRATIONS WILL MEET THE REQUIREMENTS OF THE UKIAH SEWAGE TREATMENT PLANT.

AIR, STORM WATER, AND GROUND WATER QUALITY MONITORING SHALL BE PERFORMED ACCORDING TO GENERAL AND SITE-SPECIFIC PROTOCOLS. STORM WATER MONITORING SHALL BE PERFORMED AT THE LOCATIONS AND FREQUENCIES SPECIFIED BY RWQCB ORDER NO. 85-101. STORM WATER SAMPLES WILL BE ANALYZED FOR DISSOLVED TOTAL CHROMIUM AND ARSENIC.

GROUND WATER SHALL BE MONITORED IN ON-SITE AND OFF-SITE WELLS INSTALLED SPECIFICALLY FOR THE CWP PROJECT. GROUND WATER MONITORING INCLUDES WATER LEVEL MEASUREMENTS AND WATER QUALITY ANALYSES. THE GROUND WATER SAMPLES SHALL BE ANALYZED FOR DISSOLVED TOTAL CHROMIUM, AS SPECIFIED IN RWQCB REVISED MONITORING AND REPORTING PROGRAM NO.85-101, ISSUED IN MAY 1987, AND ANY SUBSEQUENT ORDER, AS APPROPRIATE. MONITORING LOCATIONS AND FREQUENCIES ARE SUBJECT TO CHANGE AS REMEDIATION PROCEEDS.

MONITORING SHALL BE PERFORMED ACCORDING TO THE PROCEDURES OUTLINED IN THE "GROUND WATER/STORM WATER MONITORING PROTOCOL" DATED AUGUST 1987, PREPARED SPECIFICALLY FOR THE CWP FACILITY. THE MONITORING DATA SHALL BE REVIEWED PERIODICALLY TO EVALUATE THE EFFECTIVENESS OF THE RAP, AND RECOMMENDATIONS AND MODIFICATIONS SHALL BE MADE AS APPROPRIATE. THE MONITORING DATA AND RESULTS OF THESE EVALUATIONS SHALL BE REPORTED TO THE RWQCB AS REQUIRED BY THE REVISED MONITORING AND REPORTING PROGRAM NO. 85-101.

2.6 ALLOCATION OF FINANCIAL RESPONSIBILITY

CWP HAS OWNED AND OPERATED THE UKIAH FACILITY SINCE 1971 AND WILL BE RESPONSIBLE FOR IMPLEMENTATION OF THE RAP. THE PROVISIONS FOR FINANCIAL ASSURANCE ARE PROVIDED IN SECTION 9.0 OF THIS REPORT.

#SD

3.0 SITE DESCRIPTION

THIS SECTION PROVIDES A SUMMARY OF BACKGROUND INFORMATION PERTINENT TO THE RAP, INCLUDING THE LOCATION, HISTORY, AND A PHYSICAL DESCRIPTION OF THE SITE. THE CONTENT AND FORMAT OF THIS SECTION ARE GENERALLY CONSISTENT WITH THE RAP GUIDELINES PROVIDED BY THE DHS (SEPTEMBER 1987).

#SLC

3.1 SITE LOCATION

THE CWP FACILITY IS LOCATED AT THE INTERSECTION OF PLANT ROAD AND TAYLOR DRIVE IN AN UNINCORPORATED AREA OF MENDOCINO COUNTY, ABOUT 3 MILES SOUTH OF UKIAH, CALIFORNIA. THE SITE LOCATION IS SHOWN IN FIGURE 1. THE SITE COVERS AN AREA OF APPROXIMATELY 8 ACRES AND IS LOCATED IN SECTION 22 OF TOWNSHIP 15 NORTH, RANGE 12 WEST, RELATIVE TO THE MOUNT DIABLO BASELINE AND MERIDIAN. FOR THE PURPOSE OF THIS RAP, THE "SITE" REFERS TO THE AREA BOUNDED BY US HIGHWAY 101 TO THE WEST, PLANT ROAD TO THE NORTH, TAYLOR DRIVE TO THE EAST, AND AN UNPAVED TRACK TO THE SOUTH. THE "STUDY AREA" REFERS TO THE AREA BOUNDED BY PLANT ROAD AND THE UKIAH SEWAGE DISPOSAL FACILITY TO THE NORTH, THE RUSSIAN RIVER TO THE EAST, ROBINSON CREEK TO THE SOUTH, AND US HIGHWAY 101 TO THE WEST. THE STUDY AREA IS DELINEATED IN FIGURE 1. THE SITE AND VICINITY IS SHOWN IN FIGURE 2.

#SH
3.2 SITE HISTORY

THIS SECTION INCLUDES A BRIEF DESCRIPTION OF WOOD PRESERVING OPERATIONS AT THE SITE; THE TYPE OF CHEMICALS HANDLED; AND A CHRONOLOGY OF SITE CONTAMINATION, INVESTIGATION, AND INTERIM REMEDIAL MEASURES.

3.2.1 WOOD PRESERVING OPERATIONS

CWP BEGAN WOOD PRESERVING OPERATIONS AT THE SITE IN 1971 AND THE FACILITY HAS OPERATED CONTINUOUSLY UP TO THE PRESENT DATE. IT IS BELIEVED THAT PRIOR TO 1971, THE LAND WAS USED FOR AGRICULTURAL PURPOSES. THE WOOD PRESERVING OPERATIONS AND FACILITIES HAKE BEEN PERIODICALLY UPGRADED SINCE 1971 BY IMPLEMENTING SURFACE RUNOFF CONTROL MEASURES, SURFACE PAVING, CONSTRUCTION OF CANOPIES OVER WOOD TREATMENT AREAS, AND THE DEVELOPMENT OF TREATED WOOD STORAGE AND HANDLING PROCEDURES.

THE WOOD PRESERVING OPERATION AT THE SITE INVOLVES THE USE OF A CHEMICAL MIX CONSISTING OF 65.5 PERCENT SODIUM DICHROMATE, 18.3 PERCENT COPPER SULFATE, AND 16.4 PERCENT ARSENIC ACID. A DILUTE SOLUTION OF THE CHEMICAL MIX, CONTAINING THE EQUIVALENT OF 1.5 PERCENT BY WEIGHT OF CRO3, CUO, AND AS2O5, IS USED TO BATHE THE LUMBER IN PRESSURIZED RETORT CHAMBERS. AFTER EACH TREATMENT, THE RETORT CHAMBERS ARE DRAINED AND THE PRESERVING SOLUTION IS RECYCLED INTO THE WORKING SOLUTION TANK. RESIDUAL SOLUTION DRAINING FROM THE RETORT CHAMBERS AND DRIPPINGS FROM THE FRESHLY TREATED WOOD ARE COLLECTED IN CONCRETE-LINED SUMPS AND ARE ALSO RECYCLED INTO THE CHEMICAL MIX TANK VIA TEMPORARY HOLDING TANKS. THE SOLUTION TRANSFER TAKES PLACE THROUGH ABOVE-GROUND PVC PIPES. A PLAN OF THE SITE, INCLUDING THE FACILITIES MENTIONED ABOVE, IS SHOWN IN FIGURE 2.

3.2.2 CHEMICAL RELEASES

CONCERNS REGARDING THE POSSIBLE RELEASE OF WOOD PRESERVING CHEMICALS FROM THE CWP SITE WERE RAISED BY THE COUNTY OF MENDOCINO, THE DEPARTMENT OF FISH AND GAME, AND THE RWQCB IN EARLY 1972. A CHRONOLOGY OF THE SUBSEQUENT INTERACTION BETWEEN THE REGULATORY AGENCIES AND CWP IS PRESENTED IN APPENDIX A. THE CUMULATIVE DRIPPINGS FROM TREATED WOOD OVER THE YEARS ARE BELIEVED TO HAVE RESULTED IN NEAR-SURFACE SOIL CONTAMINATION AT THE SITE, PARTICULARLY DURING THE EARLY YEARS OF OPERATION WHEN THE TREATMENT AND TREATED WOOD STORAGE AREAS WERE NOT ALL PAVED. CURRENTLY, ALL BUT THE SOUTH AND SOUTHEAST PORTIONS OF THE SITE (AS SHOWN IN FIGURE 2) ARE PAVED WITH ASPHALT OR CONCRETE.

3.2.3 PREVIOUS STUDIES

AS INDICATED IN SECTION 3.2.2, THE RWQCB FIRST BECAME INVOLVED IN THE ENVIRONMENTAL ASPECTS OF CWP'S WOOD PRESERVING OPERATIONS IN EARLY 1972. THE RWQCB'S SPECIFIC CONCERNS WERE RELATED TO POTENTIAL SURFACE WATER AND GROUND WATER CONTAMINATION. APPENDIX A PROVIDES A CHRONOLOGY OF EVENTS RELATED TO ENVIRONMENTAL ACTIVITIES AT THE SITE.

ON JUNE 13, 1980, RWQCB STAFF COLLECTED SAMPLES OF SURFACE WATER RUNOFF WHICH WERE FOUND TO CONTAIN WOOD PRESERVING CHEMICALS. IN SEPTEMBER 1980, THE RWQCB REQUESTED THAT CWP ASSESS AND REPORT THE POSSIBLE IMPACT OF WOOD PRESERVING OPERATIONS ON SOIL AND GROUND WATER QUALITY BENEATH THE SITE. THIS ASSESSMENT, PERFORMED BY H. ESMAILI & ASSOCIATES, INC. (AUGUST 1981) AND REFERRED TO AS THE PHASE I STUDY, INCLUDED THE INSTALLATION OF SIX SHALLOW GROUND WATER MONITORING WELLS (WELLS CWP-1 THROUGH CWP-6). THE LOCATIONS OF THESE MONITORING WELLS ARE SHOWN IN FIGURE 2 AND THE CONSTRUCTION DETAILS ARE SUMMARIZED IN TABLE 1. THE INVESTIGATION INDICATED

ELEVATED CHROMIUM CONCENTRATIONS IN NEAR-SURFACE SOIL SAMPLES AND GROUND WATER SAMPLES COLLECTED FROM WELLS CWP-1 THROUGH CWP-6. NO ABNORMAL CONCENTRATIONS OF ARSENIC OR COPPER WERE FOUND IN ANY OF THE GROUND WATER SAMPLES.

IN OCTOBER 1981, CWP INSTALLED WELLS CWP-7, CWP-8, AND CWP-9 ALONG THE EASTERN SITE BOUNDARY TO EVALUATE POSSIBLE OFF-SITE MIGRATION. IN DECEMBER 1981, THE RWQCB INSTALLED OFF-SITE MONITORING WELLS FPT-1A, FPT-1B, FPT-2A, AND FPT-3 TO THE EAST OF THE SITE. THE ANALYSIS OF GROUND WATER SAMPLES FROM THESE WELLS CONFIRMED THAT OFF-SITE MIGRATION OF CHROMIUM HAD OCCURRED.

ADDITIONAL STUDIES WERE SUBSEQUENTLY INITIATED TO DETERMINE THE EXTENT OF GROUND WATER CONTAMINATION AND EVALUATE THE FEASIBILITY OF CONTAINING CONTAMINATED GROUNDWATER ON SITE. THIS PHASE II STUDY, CONDUCTED BY J. H. KLEINFELDER & ASSOCIATES (NOVEMBER 1982), INCLUDED THE INSTALLATION OF SEVEN ADDITIONAL ON-SITE GROUND WATER MONITORING WELLS (CWP-10 THROUGH CWP-16) AND SHOWED THAT THE VERTICAL EXTENT OF CHROMIUM, COPPER, AND ARSENIC IN SOIL AND GROUND WATER WAS LIMITED. THE LOCATIONS OF THE GROUND WATER MONITORING WELLS INSTALLED DURING THE PHASE I AND PHASE II STUDIES ARE SHOWN IN FIGURE 2. ADDITIONAL OFF-SITE GROUND WATER MONITORING WELLS (WELLS AT-1, AT-2, AT-3, FPT-4, AND FPT-5) WERE SUBSEQUENTLY INSTALLED BY KLEINFELDER AND CWP TO FURTHER DELINEATE OFF-SITE CONTAMINATION.

IN OCTOBER 1983, ACTING ON ITS OWN INITIATIVE BUT WITHOUT REGULATORY AGENCY APPROVAL OR OVERSIGHT, CWP CONSTRUCTED A BENTONITE SLURRY CUTOFF WALL, NEAR THE EASTERN SITE BOUNDARY, TO INTERCEPT AND LIMIT THE MIGRATION OF CHROMIUM INTO GROUND WATER. CWP ALSO CONSTRUCTED A GROUND WATER EXTRACTION TRENCH IMMEDIATELY TO THE WEST AND HYDRAULICALLY UPGRADIENT OF THE SLURRY CUTOFF WALL. THE APPROXIMATE LOCATIONS OF THE SLURRY CUTOFF WALL AND THE EXTRACTION TRENCH ARE SHOWN IN FIGURE 2. AS AN INTERIM REMEDIAL MEASURE, CWP BEGAN EXTRACTING GROUND WATER FROM THE TRENCH VIA A CENTRAL SUMP, KNOWN AS WELL HL-7, EQUIPPED WITH AN ELECTRIC SUBMERSIBLE PUMP. THE EXTRACTED GROUND WATER WAS RECYCLED BACK INTO THE WOOD PRESERVING OPERATION. ALSO, AS PART OF THE OVERALL EFFORT TO IMPROVE SITE CONDITIONS, CWP ERECTED CANOPIES OVER THE RETORT AREA. THESE COVERS LIMIT THE EXPOSURE OF FRESHLY TREATED WOOD TO PRECIPITATION AND REDUCE SURFACE WATER RUNOFF FROM THIS AREA. THESE INTERIM REMEDIAL MEASURES ARE DESCRIBED IN MORE DETAIL IN SECTION 5.0.

AFTER REVIEWING THE FINDINGS OF PHASES I AND II OF THE INVESTIGATION, THE REGULATORY AGENCIES REQUESTED THAT CWP FURTHER DEFINE THE DISTRIBUTION OF CHROMIUM, ARSENIC, AND COPPER IN SOIL AND GROUND WATER. (D'APPOLONIA) CONSULTING ENGINEERS, INC. (D'APPOLONIA) WAS RETAINED BY CWP TO PERFORM THIS INVESTIGATION AND ADDRESS THE AGENCIES' CONCERNS. THE INVESTIGATION INCLUDED A SERIES OF SOIL SAMPLING BORINGS, BORINGS S-1 THROUGH S-26 (D'APPOLONIA/IT CORPORATION, MAY 1984)(1), THE LOCATIONS OF WHICH ARE SHOWN IN FIGURE 2. THE INVESTIGATION SHOWED THAT THE TOP 1 TO 2 FEET OF THE SOIL PROFILE AROUND THE RETORT AND RAIL LINE AREAS CONTAINED ELEVATED CONCENTRATIONS OF CHROMIUM AND ARSENIC. IT IS NOTED, HOWEVER, THAT NO SOIL SAMPLES WERE COLLECTED FROM BENEATH THE ACTUAL RETORTS. THE GROUND WATER QUALITY DATA INDICATED ELEVATED CONCENTRATIONS OF CHROMIUM IN MONITORING WELLS LOCATED NEAR THE RETORT AREAS. CHROMIUM CONCENTRATIONS IN GROUND WATER GENERALLY DECREASED WITH DISTANCE FROM THE RETORT AREA IN THE DOWNGRADIENT DIRECTION.

SUBSEQUENT TO REGULATORY AGENCY REVIEW OF THE FINDINGS OF THE D'APPOLONIA INVESTIGATION, ANOTHER STUDY WAS INITIATED TO FURTHER DEFINE THE EXTENT AND MIGRATION BEHAVIOR OF CHROMIUM IN GROUNDWATER AND EVALUATE VIABLE REMEDIAL ACTION ALTERNATIVES TO ADDRESS CONTAMINATED SOIL AND GROUND WATER. THIS INVESTIGATION (IT CORPORATION, JUNE 1985) LED TO THE FOLLOWING CONCLUSIONS:

- CONTAINMENT OF CONTAMINATED SOIL AND REMEDIATION OF THE CONTAMINATED WATER-BEARING ZONE BY HYDRAULIC CONTROL MEASURES, SUCH AS GROUND WATER EXTRACTION, WAS FEASIBLE.

- THE MAJORITY OF THE EXTRACTED GROUND WATER COULD BE REUSED IN CWP'S WOOD PRESERVING OPERATIONS AND THE EXCESS COULD BE TREATED COST-EFFECTIVELY BY THE EXISTING ELECTROCHEMICAL UNIT AT THE SITE.

SUBSEQUENT TO THIS INVESTIGATION, A LARGE-DIAMETER EXTRACTION WELL, WELL CWP-18, WAS INSTALLED NEAR THE RETORT AREA TO CONTAIN CONTAMINATED GROUND WATER TO THE EXTENT POSSIBLE. ALSO, AN INJECTION WELL, WELL CWP-19, WAS INSTALLED HYDRAULICALLY UPGRADIENT OF THE RETORT AREA AND THE EXISTING CHROMIUM PLUME SO THAT EXCESS TREATED WATER COULD BE INJECTED BACK INTO THE WATER-BEARING ZONE. THE RETORT AREA EXTRACTION WELL AND THE UPGRADIENT INJECTION WELL ARE DESCRIBED FURTHER IN SECTION 5.0.

IN RESPONSE TO CONCERNS EXPRESSED BY THE REGULATORY AGENCIES REGARDING THE EFFECTIVENESS OF THE EXTRACTION TRENCH AND THE SLURRY CUTOFF WALL IN REMEDIATING AND CONTAINING THE CHROMIUM PLUME NEAR THE EASTERN SITE BOUNDARY, GEOSYSTEM PERFORMED A NUMBER OF INVESTIGATIONS TO EVALUATE AQUIFER PARAMETERS, ASSESS THE LEACHING BEHAVIOR OF SOILS, AND ESTIMATE THE DURATION OF AQUIFER CLEANUP (GEOSYSTEM, MARCH 1986; NOVEMBER 1986). A NUMBER OF ADDITIONAL ONSITE AND OFF-SITE MONITORING WELLS (WELLS CWP-22, AT-4, AND AT-5) WERE ALSO INSTALLED TO INVESTIGATE GROUND WATER QUALITY' HYDRAULICALLY DOWNGRADIENT OF THE SLURRY CUTOFF WALL. THE LOCATIONS OF THE ON-SITE AND OFF-SITE GROUND WATER MONITORING WELLS ARE SHOWN IN FIGURE 2, AND THE WELL CONSTRUCTION DETAILS ARE SUMMARIZED IN TABLE 1.

IN ADDITION TO THE STUDIES PERFORMED BY THEIR CONSULTANTS, CWP CONDUCTED REGULAR GROUND WATER MONITORING USING THEIR OWN RESOURCES. THE GROUND WATER MONITORING PROGRAM WAS ORIGINALLY SPECIFIED BY THE RWQCB IN ORDER NO. 83-93, WHICH WAS ADOPTED IN JUNE 1983. ORDER NO. 83-93 HAS BEEN REVISED AND/OR SUPERSEDED SEVERAL TIMES AS ADDITIONAL MONITORING WELLS HAVE BEEN INSTALLED AND EXISTING WELLS ABANDONED OR DELETED FROM THE MONITORING PROGRAM. THE CURRENT MONITORING PROGRAM IS IN ACCORDANCE WITH THE REQUIREMENTS OF THE MOST RECENT REVISION OF THE RWQCB ORDER (MAY 1987). MONITORING INCLUDES THE COLLECTION AND ANALYSIS OF STORM WATER SAMPLES FOR CHROMIUM AND ARSENIC. THE MONITORING PROGRAM ALSO INCLUDES GROUND WATER LEVEL MEASUREMENT AND THE COLLECTION AND ANALYSIS GROUNDWATER SAMPLES FOR DISSOLVED TOTAL CHROMIUM. GROUND WATER MONITORING IS PERFORMED ACCORDING TO THE GROUND WATER MONITORING PROTOCOL (GEOSYSTEM, AUGUST 3987) PREPARED SPECIFICALLY FOR THE CWP PROJECT.

THE WATER LEVEL MEASUREMENT AND GROUND WATER QUALITY DATA OBTAINED BY CWP, CONSULTANTS ACTING ON BEHALF OF CWP, AND REGULATORY AGENCY PERSONNEL HAVE BEEN COMPILED BY GEOSYSTEM ON A COMPUTER-BASED DATA MANAGEMENT SYSTEM. A SUMMARY OF THESE DATA IS PRESENTED IN APPENDIX B. A SUMMARY OF THE STORM WATER QUALITY DATA IS PRESENTED IN APPENDIX C, AND A SUMMARY OF THE SOIL QUALITY ANALYSES PERFORMED IS PRESENTED IN APPENDIX D.

BECAUSE OF THE LARGE VOLUME OF PREVIOUSLY REPORTED INVESTIGATIONS, THIS SUMMARY IS INTENDED TO PROVIDE ONLY A BRIEF INTRODUCTION TO THE CHARACTERIZATION STUDIES PERFORMED AT THE SITE. ADDITIONAL DETAILS AND INTERPRETATION OF THE FINDINGS OF THESE INVESTIGATIONS ARE PRESENTED IN SECTION 4.0 AND IN THE SUBJECT-SPECIFIC TECHNICAL REPORTS REFERENCED.

3.3 PHYSICAL DESCRIPTION

THIS SECTION INCLUDES DESCRIPTIONS OF TOPOGRAPHY, PHYSICAL SETTING, DEMOGRAPHY, CLIMATOLOGY, SENSITIVE STRUCTURES, AND POTENTIAL RECEPTORS.

3.3.1 TOPOGRAPHY

THE CWP SITE IS LOCATED IN THE UKIAH VALLEY. IN THE VICINITY OF THE SITE, THE VALLEY FLOOR IS ABOUT 2.5 MILES WIDE. THE VALLEY TAPERS TO AN UNNAMED, NARROW GORGE, SEVERAL HUNDRED FEET WIDE, AT A POINT ABOUT 4.5 MILES SOUTH OF THE SITE. THE RUSSIAN RIVER FLOWS SOUTH THROUGH THIS GORGE FROM THE UKIAH VALLEY INTO HOPLAND VALLEY. THE VALLEY FLOOR AT THE SITE IS AT AN ELEVATION OF ABOUT 565 TO 585 FEET ABOVE MEAN SEA LEVEL (MSL) AND SLOPES GENTLY TO THE SOUTH ALONG THE AXIS OF THE VALLEY, AT A GRADIENT OF ABOUT 0.2 PERCENT (1 IN 500).

THE UKIAH VALLEY IS BOUNDED BY STEEP MOUNTAINS TO THE EAST AND WEST. THOSE TO THE EAST OF THE SITE ARE KNOWN AS THE MAYACMAS MOUNTAINS AND RISE TO OVER 3,600 FEET ABOVE MSL. THE MOUNTAINS TO THE WEST INCLUDE CLELAND MOUNTAIN AND ELLEDGE PEAK WHICH RISE TO OVER 2,500 FEET ABOVE MSL. THE SLOPES OF THE MOUNTAINS BOUNDING THE UKIAH VALLEY RANGE FROM ABOUT 12 TO 67 PERCENT.

STEEP-SIDED VALLEYS, APPROXIMATELY PERPENDICULAR TO THE AXIS OF THE UKIAH VALLEY, ARE ALSO PROMINENT TOPOGRAPHIC FEATURES. THESE VALLEYS TYPICALLY CONTAIN TRIBUTARIES TO THE RUSSIAN RIVER. THE MOST SIGNIFICANT OF THESE WITH RESPECT TO THE CWP SITE IS THE VALLEY OCCUPIED BY ROBINSON CREEK, WHICH ENTERS THE UKIAH VALLEY FROM THE WEST, APPROXIMATELY 4,500 FEET SOUTH OF THE CWP SITE, AS SHOWN IN FIGURE 1.

THE TOPOGRAPHY OF THE CWP SITE ITSELF HAS BEEN LOCALLY ALTERED BY GRADING FOR DRAINAGE AND FOUNDATION PURPOSES. IN GENERAL, HOWEVER, THE LAND SURFACE SLOPES GENTLY TO THE EAST, TOWARDS TAYLOR DRIVE.

3.3.2 SITE FEATURES

IN TERMS OF SURFACE STRUCTURES, THE SITE FEATURES A GENERAL OFFICE IN THE NORTHWEST CORNER AND A GARAGE OR SERVICE-TYPE STRUCTURE NEAR THE CENTER OF THE SITE. THE TWO RETORTS IN WHICH LUMBER IS PRESSURE TREATED ARE ORIENTATED EAST-WEST NEAR THE WESTERN SITE BOUNDARY. EACH RETORT CHAMBER IS APPROXIMATELY 70 FEET LONG. THE RAIL LINES ASSOCIATED WITH EACH RETORT EXTEND ABOUT 140 FEET TO THE EAST. THE SUMP TO WHICH THE RETORTS DRAIN IS LOCATED AT THE EASTERN END OF THE VESSELS. THE WOOD PRESERVING SOLUTION IS RECYCLED TO, AND STORED IN, FOUR LARGE, ABOVE-GROUND TANKS ALONG THE WESTERN SITE BOUNDARY.

OTHER SIGNIFICANT SITE FEATURES INCLUDE A WALLED WORK TANK AREA IN WHICH WOOD PRESERVING SOLUTION IS MIXED. THIS WORK TANK AREA INCLUDES A LARGE CONCRETE SUMP CONTAINING "MAKE-UP" WATER. GROUND WATER EXTRACTED FROM WELLS HL-7 AND CWP-18 IS DISCHARGED TO THIS SUMP TO BE RECYCLED IN THE WOOD PRESERVING OPERATION. A LARGE, 330,000 GALLON, ABOVE-GROUND TANK IS USED TO STORE TREATED GROUND WATER.

THE MAJORITY OF THE SITE IS PAVED WITH ASPHALT CONCRETE AND IS USED FOR WOOD STORAGE. TREATED WOOD IS STORED IN THE NORTHEAST CORNER OF THE SITE. SURFACE RUNOFF FROM THIS AREA IS CONTROLLED BY ASPHALT BERMS AND COLLECTED IN A SUMP ON THE EASTERN SITE BOUNDARY, FROM WHICH IT IS RETURNED TO THE MAKE-UP WATER SUMP. THE UNPAVED AREAS OF THE SITE ARE LOCATED ALONG THE SOUTHEASTERN AND SOUTHERN SITE BOUNDARIES AND ARE GENERALLY VACANT OR USED FOR UNTREATED WOOD STORAGE.

THE CWP FACILITY IS FENCED FOR SECURITY AND IS ACCESSED VIA TWO SLIDING GATES WHICH ARE LOCKED OUTSIDE OF NORMAL BUSINESS HOURS OR USED FOR UNTREATED WOOD STORAGE.

3.3.3 SURROUNDING LAND USE

THE LARGE MAJORITY OF THE LAND SURFACE IN MENDOCINO COUNTY IS OCCUPIED BY NATIVE VEGETATION AND NON-IRRIGATED AGRICULTURE. A STUDY PERFORMED BY THE DEPARTMENT OF WATER RESOURCES (MAY 1980) PROJECTED LAND USE IN SEVERAL GROUND WATER BASINS ALONG THE RUSSIAN RIVER. IN 1974, NATIVE VEGETATION AND NON-IRRIGATED AGRICULTURE OCCUPIED OVER 185,000 ACRES IN THE UPPER RUSSIAN GROUND WATER BASIN, IN WHICH THE CWP SITE IS LOCATED. URBAN, IRRIGATED AGRICULTURE, AND RECREATIONAL LAND USE ACCOUNTED FOR APPROXIMATELY 3,400, 9,900, AND 250 ACRES, RESPECTIVELY. PROJECTIONS UP TO THE YEAR 2000 SUGGEST THAT URBAN AND IRRIGATED AGRICULTURAL LAND USE WILL INCREASE AT THE EXPENSE OF NATIVE VEGETATION AND NON-IRRIGATED AGRICULTURE. PROJECTED RECREATIONAL LAND USE REMAINS CONSTANT.

THE PRINCIPAL LAND USE IN MENDOCINO COUNTY IS FOR TIMBER PRODUCTION, WHICH PROVIDES TWO-THIRDS OF THE COUNTY'S AGRICULTURAL REVENUES. PASTURE AND RANGE LAND OCCUPIES 672,000 ACRES, WHILE FRUIT PRODUCTION, MOSTLY GRAPES AND PEARS, ACCOUNTS FOR 15,000 ACRES (COUNTY OF MENDOCINO, 1985). MAJOR LAND USES IN THE GENERAL VICINITY OF THE CWP SITE INCLUDE VINEYARDS, FRUIT AND NUT TREES, FORESTED LAND, SINGLE FAMILY RESIDENCES, AND TRANSPORTATION. LAND USE IN THE IMMEDIATE VICINITY OF THE CWP SITE INCLUDES TIMBER-RELATED FACILITIES, SEWAGE TREATMENT, FRUIT TREES (PEARS), TRANSPORTATION (US HIGHWAY 101), BUSINESS AND COMMERCIAL FACILITIES, AND VACANT LOTS. LAND USE WITHIN A 1.5 MILE RADIUS OF THE CWP SITE IS SHOWN IN FIGURE 3.

3.3.4 POPULATION DISTRIBUTION

IN 1986, THE POPULATION OF MENDOCINO COUNTY WAS 74,267, ABOUT 50 PERCENT OF WHICH RESIDED IN THE UKIAH AREA. THE POPULATION OF THE CITY OF UKIAH IN 1986 WAS 13,331 (GREATER UKIAH CHAMBER OF COMMERCE, JUNE 1987). OTHER, SMALLER COMMUNITIES IN THE VICINITY OF THE CWP SITE INCLUDE TALMAGE, LOCATED APPROXIMATELY 2 MILES TO THE NORTHEAST, AND HOPLAND, LOCATED APPROXIMATELY 10 MILES SOUTH ALONG US HIGHWAY 101.

THE MAIN POPULATION CENTER OF UKIAH IS APPROXIMATELY 3 MILES TO THE NORTH OF THE CWP SITE. IN THE VICINITY OF THE SITE, THERE ARE VERY FEW RESIDENCES. AERIAL PHOTOGRAPHS TAKEN IN APRIL 1984 INDICATE ONLY FIVE RESIDENTIAL STRUCTURES WITHIN A QUARTER-MILE RADIUS OF THE SITE BOUNDARIES. ACCORDING TO GREATER UKIAH CHAMBER OF COMMERCE RECORDS (JUNE 1987), THERE ARE AN AVERAGE OF 2.45 RESIDENTS PER DWELLING IN THE CITY OF UKIAH. USING THIS STATISTIC, IT APPEARS THAT THERE ARE LESS THAN 15 PEOPLE LIVING WITHIN A QUARTER-MILE OF THE CWP SITE.

INTERVIEWS CONDUCTED BY GEOSYSTEM PERSONNEL INDICATE THAT THERE ARE FOUR HOUSES, TWO DUPLEXES, TWO BUNK HOUSES, AND SIX MOTEL UNITS IN THE STUDY AREA WITHIN ONE-HALF MILE OF THE CWP SITE. IT IS NOTED THAT THE MOTEL UNITS ARE USED TO HOUSE SEASONAL WORKERS ASSOCIATED WITH THE ALEX THOMAS PEAR PACKING FACILITY. DURING THE WINTER MONTHS, ABOUT 20 PEOPLE MAY OCCUPY THESE RESIDENCES.

IN THE PEAK FRUIT HARVESTING SEASON, HOWEVER, THIS NUMBER MAY INCREASE TO ABOUT 100.

3.3.5 CLIMATOLOGY

THIS SECTION CHARACTERIZES THE CLIMATE IN THE VICINITY OF THE CWP SITE IN TERMS OF TEMPERATURE, PRECIPITATION, AND WIND SPEED AND DIRECTION. THE DATA HAVE BEEN OBTAINED FROM VARIOUS LOCATIONS IN AND AROUND UKIAH; HOWEVER, IT IS BELIEVED THAT THE VARIATIONS IN CLIMATE OVER THE RELATIVELY SMALL DISTANCES FROM THE CWP SITE ARE NOT SIGNIFICANT.

3.3.5.1 TEMPERATURE

UKIAH HAS A RELATIVELY MILD CLIMATE, CHARACTERIZED BY DRY, HOT SUMMERS AND COOL, WET WINTERS. BASED ON RECORDS AVAILABLE FROM 1877 TO 1980, THE AVERAGE AIR TEMPERATURE REPORTEDLY VARIES FROM 46.0 DEGREES FAHRENHEIT IN JANUARY TO 73.7 DEGREES FAHRENHEIT IN JULY, WITH AN AVERAGE ANNUAL AIR TEMPERATURE OF 59.2 DEGREES FAHRENHEIT. THE MAXIMUM AND MINIMUM TEMPERATURES RECORDED IN UKIAH SINCE RECORDS HAVE BEEN MAINTAINED WERE 114 AND 12 DEGREES FAHRENHEIT, RESPECTIVELY (FARRAR, JULY 1986). MEAN MONTHLY AIR TEMPERATURE DATA FOR UKIAH ARE PRESENTED IN TABLE 2.

3.3.5.2 PRECIPITATION

BASED ON RECORDS AVAILABLE FROM 1877 TO 1980, THE MEAN ANNUAL PRECIPITATION IN UKIAH IS 36.27 INCHES. THE RECORDS INDICATE, HOWEVER, THAT CONSIDERABLE VARIATION IN ANNUAL PRECIPITATION IS COMMON IN THE UKIAH AREA WITH VARIATIONS OF UP TO 30 INCHES OCCURRING IN CONSECUTIVE YEARS. THE MAXIMUM AND MINIMUM PRECIPITATION RECORDED DURING THE PERIOD OF RECORD WAS 60.97 AND 13.09 INCHES IN 1890 AND 1924, RESPECTIVELY (FARRAR, JULY 1986). ADDITIONAL PRECIPITATION DATA, REPORTEDLY COMPILED FROM US WEATHER BUREAU REPORTS AND UKIAH FIRE DEPARTMENT RECORDS, INDICATE THAT TOTAL PRECIPITATION WAS 70.19 INCHES IN THE 1982-1983 SEASON (SAVINGS BANK OF MENDOCINO COUNTY, 1987).

THE MAJORITY OF THE PRECIPITATION FALLS AS RAIN BETWEEN THE BEGINNING OF OCTOBER AND THE END OF APRIL, WITH MORE THAN 50 PERCENT OF THE ANNUAL RAINFALL OCCURRING IN DECEMBER, JANUARY, FEBRUARY. MEAN MONTHLY PRECIPITATION DATA, BASED ON RECORDS MAINTAINED FROM 1877 TO 1980, ARE SUMMARIZED IN TABLE 2. ON-SITE PRECIPITATION MEASUREMENTS HAVE ALSO BEEN RECORDED BY CWP PERSONNEL SINCE DECEMBER 1981. THESE DATA, SUMMARIZED IN TABLE 3, INDICATE THAT THE TOTAL ANNUAL PRECIPITATION HAS RANGED FROM A LOW OF 17.05 INCHES IN 1985 TO A HIGH OF 51.34 INCHES IN 1983. THESE DATA ARE CONSISTENT WITH MEASUREMENTS RECORDED ELSEWHERE IN THE UKIAH AREA AND ILLUSTRATE THE LARGE VARIATIONS IN ANNUAL PRECIPITATION MENTIONED ABOVE.

3.3.5.3

WIND DATA, RECORDED FROM 1950 TO 1964 AT TWO LOCATIONS AT THE UKIAH MUNICIPAL AIRPORT, INDICATE THAT THE MEAN ANNUAL WIND SPEED WAS 3.7 TO 3.9 MILES PER HOUR (MPH). WIND SPEEDS ARE GENERALLY HIGHER FROM APRIL TO JULY AND ARE LOWEST IN NOVEMBER AND DECEMBER. THE HIGHEST MEAN MONTHLY WIND SPEED RECORDED WAS 6.5 MPH IN JUNE 1959. THE LOWEST WAS 0.4 MPH IN DECEMBER 1963 (CALIFORNIA ENERGY COMMISSION, APRIL 1985).

THE PREVAILING WIND DIRECTION REPORTEDLY' NORTHWEST TO WEST (GREATER UKIAH CHAMBER OF COMMERCE, JUNE 1987). THE MEAN MONTHLY AND ANNUAL WIND SPEEDS FOR THE PERIOD OF RECORD ARE SUMMARIZED IN TABLE 2.

3.3.6 LOCATION OF WATER WELLS

A WELL INVENTORY WAS PERFORMED TO LOCATE WATER WELLS IN THE VICINITY OF THE CWP SITE AND TO DETERMINE THEIR STATUS. SOURCES OF INFORMATION INCLUDED PRIMARILY RECORDS MADE AVAILABLE BY THE DWR (JUNE 1956; OCTOBER 1986) AND WILLOW COUNTY WATER DISTRICT (WCWD). IN ADDITION, WELL LOGS AVAILABLE AT DWR IN SACRAMENTO, CALIFORNIA WERE REVIEWED AND THE LOCATIONS OF WELLS IN THE IMMEDIATE VICINITY OF THE CWP SITE WERE VERIFIED BY FIELD INSPECTION. THE WELL INVENTORY FOCUSED ON WELL LOCATIONS, WELL CONSTRUCTION DETAILS, STRATIGRAPHY, AND THE BENEFICIAL USES OF THE EXTRACTED WATER.

THE WELL INVENTORY INDICATED THE PRESENCE OF SEVERAL DOZEN WELLS IN THE VICINITY OF THE SITE. THE LOCATIONS OF THESE WELLS ARE SHOWN IN FIGURE 4. IT SHOULD BE NOTED THAT, WITH THE EXCEPTION OF THE RECORDS MAINTAINED BY WCUD, THE INFORMATION AVAILABLE ON WELL LOCATIONS AND CONSTRUCTION

DETAILS IS OFTEN VAGUE AND INCOMPLETE. FEW OF THE WELLS HAVE BEEN IDENTIFIED ACCORDING TO THE STATE WELL-NUMBERING SYSTEM AND THE INFORMATION REGARDING WELL LOCATIONS IS TYPICALLY IMPRECISE AND INSUFFICIENT TO LOCATE THE WELLS ACCURATELY. GEOSYSTEM HAS ATTEMPTED TO LOCATE WELLS AS ACCURATELY AS POSSIBLE, BASED ON THE AVAILABLE INFORMATION, AND IDENTIFY THE WELLS ACCORDING TO THE STATE WELL-NUMBERING SYSTEM. THE WELL LOCATIONS SHOWN IN FIGURE 4 MUST, HOWEVER, BE CONSIDERED APPROXIMATE. THE AVAILABLE WELL CONSTRUCTION DETAILS AND BENEFICIAL USES OF GROUND WATER ARE SUMMARIZED IN TABLE 4. IT IS NOTED THAT THE NEAREST WATER-PRODUCING WELL TO THE CWP SITE IS WELL 14N/12W-4D1, WHICH IS LOCATED ABOUT 1,000 FEET TO THE SOUTH.

ACCORDING TO INFORMATION OBTAINED BY GEOSYSTEM PERSONNEL, THIS WELL IS CAPPED AND NOT CURRENTLY ACTIVE. WELL 14N/12W-4E1, HOWEVER, APPEARS TO BE THE NEAREST WATER-PRODUCING WELL. ACCORDING TO THE OWNERS OF THE PROPERTY, THE WATER IS USED FOR DOMESTIC AND IRRIGATION PURPOSES. THIS WELL IS LOCATED ABOUT 1,500 FEET TO THE SOUTH OF THE CWP SITE.

3.3.7 POTENTIAL BIOLOGICAL RECEPTORS

POTENTIAL BIOLOGICAL RECEPTORS OF CONTAMINANTS ORIGINATING FROM THE CWP SITE ARE CONSIDERED TO INCLUDE NATIVE VEGETATION, FRUIT TREES, AQUATIC LIFE IN THE RUSSIAN RIVER AND ITS TRIBUTARIES, AND WILD ANIMALS AND BIRDS.

VEGETATION TYPES FOUND IN THE UPPER PORTION OF THE RUSSIAN RIVER WATERSHED INCLUDE HARDWOOD AND MIXED FOREST, CHAPARRAL, GRASSLAND, ORCHARDS AND VINEYARDS, AND RIPARIAN WOODLAND SPECIES. THE RIPARIAN WOODLAND SPECIES INCLUDE MULE FACT, SANDBAR WILLOW, RED WILLOW, AND FREMONT COTTONWOOD (MCBRIDE AND STRAHAN, 1981; JARA, 1974). IT IS NOTED THAT MOST OF THE LAND LOCATED IMMEDIATELY DOWNGRADIENT OF THE CWP SITE IS OCCUPIED BY PEAR ORCHARDS. THE SURFACE DRAINS AND CREEKS LOCATED DOWNSTREAM OF THE CWP FACILITY ARE SEASONALLY VEGETATED WITH TULLEYS, SOUR DOCK, ANISE, WILD ROSE, PEPPERMINT, AND CATTAILS.

THE RUSSIAN RIVER IS IMPORTANT AS A SPAWNING GROUND FOR ANADROMOUS FISH, OF WHICH THE PRINCIPAL VARIETIES ARE STEELHEAD TROUT AND SILVER (OR COHO) SALMON. OTHER FISH INHABITING THE BASIN INCLUDE KING (OR CHINOOK) SALMON, SMALL-MOUTH BASS, AMERICAN SHAD, STRIPED BASS, AND WHITE CATFISH.

THE RUSSIAN RIVER BASIN SUPPORTS A WIDE RANGE OF WILDLIFE SPECIES, INCLUDING A SUBSTANTIAL POPULATION OF BLACKTAILED DEER, BANDTAILED PIGEONS, AND PHEASANTS. SEVERAL SPECIES OF SMALL MAMMALS ASSOCIATED WITH AGRICULTURAL LAND USE, I.E. RATS, MICE, AND RABBITS, ARE ALSO FOUND IN THE AREA. THE RUSSIAN RIVER BASIN SUPPORTS A VARIETY OF RESIDENT AND NON-RESIDENT WATERFOWL WHICH UTILIZE THE RIVER HABITAT FOR NESTING AND REFUGE (US ARMY CORPS OF ENGINEERS, MARCH 1982).

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4.0 SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

THIS SECTION SUMMARIZES THE GEOLOGIC, HYDROLOGIC, AND SOIL/GROUND WATER QUALITY DATA GENERATED DURING THE REMEDIAL INVESTIGATIONS. DETAILS OF THE REMEDIAL INVESTIGATIONS HAVE BEEN SUBMITTED IN A NUMBER OF PREVIOUS TECHNICAL REPORTS, WHICH ARE REFERENCED AS APPROPRIATE. THE CONTENT AND FORMAT OF THE SUMMARY OF REMEDIAL INVESTIGATION FINDINGS IS IN GENERAL CONFORMANCE WITH THE RAP GUIDELINES (DHS, SEPTEMBER 1987).

4.1 GEOLOGY

THE DISCUSSION OF REGIONAL GEOLOGY AND STUDY AREA STRATIGRAPHY IS BASED PRIMARILY ON PUBLISHED WATER SUPPLY PAPERS/GEOLOGIC REPORTS BY GOVERNMENT AGENCIES, SITE-SPECIFIC REPORTS PREPARED BY CWP'S CONSULTANTS, AND DISCUSSIONS WITH REGULATORY AGENCY PROJECT PERSONNEL. THE DISCUSSION IS INTENDED TO HELP INTERPRET THE STRATIGRAPHY ENCOUNTERED AT THE SITE IN THE CONTEXT OF THE OVERALL, REGIONAL GEOLOGY AND TO IDENTIFY AND CHARACTERIZE THE GEOLOGIC UNITS PERTINENT TO THE CWP PROJECT. THE PRIMARY REFERENCE FOR REGIONAL GEOLOGY IS A US GEOLOGICAL SURVEY (USGS) REPORT ENTITLED "GROUND WATER RESOURCES IN MENDOCINO COUNTY, CALIFORNIA" (FARRAR, JULY 1986). OTHER SOURCES OF INFORMATION ARE REFERENCED AS APPROPRIATE.

4.1.1 REGIONAL GEOLOGY

MENDOCINO COUNTY IS LOCATED LARGELY WITHIN THAT PART OF THE COAST RANGES GEOMORPHIC PROVINCE KNOWN AS THE MENDOCINO RANGE. THE MENDOCINO RANGE IS CHARACTERIZED BY ROCKS OF THE FRANCISCAN

COMPLEX. THE GEOLOGIC UNITS EXPOSED AT THE SURFACE IN THE UKIAH VALLEY MAY BE CATEGORIZED AS BASEMENT ROCKS OR VALLEY FILL.

BASEMENT ROCKS ARE CONSIDERED TO INCLUDE ALL PRE-PLIOCENE FORMATIONS. ABOUT 95 PERCENT OF THE SURFACE EXPOSURES CONSIST OF BASEMENT ROCKS OF THE FRANCISCAN COMPLEX. IN THE VICINITY OF THE SITE, THE FRANCISCAN COMPLEX HAS BEEN DIVIDED INTO THE COASTAL BELT AND THE CENTRAL BELT BASED ON LITHOLOGIC AND STRUCTURAL DIFFERENCES. THE DIVISION BETWEEN THE TWO IS LOCATED ALONG THE AXIS OF THE UKIAH VALLEY, WITH THE COASTAL BELT FORMING THE MOUNTAINS THAT BOUND THE VALLEY TO THE WEST, AND THE CENTRAL BELT FORMING THE MAYACMAS MOUNTAINS TO THE EAST. VALLEY FILL REFERS TO GEOLOGIC UNITS OF QUATERNARY AGE OR THOSE THAT SPAN LATE TERTIARY AND QUATERNARY AGE. VALLEY FILL DEPOSITS ARE CONFINED TO SEVERAL SMALL BASINS ALONG MAJOR SURFACE DRAINAGE FEATURES AND THE THIN ALLUVIUM IN STREAM CHANNELS.

PHYSIOGRAPHICALLY, THE SITE IS LOCATED IN THE UKIAH VALLEY, A NORTH-SOUTH TRENDING ALLUVIAL BASIN FORMED BY THE RUSSIAN RIVER AND ITS TRIBUTARIES. THE VALLEY FILL WITHIN THE UKIAH VALLEY HAS BEEN SUBDIVIDED BY FARRAR (JULY 1986) INTO THREE DISTINCT UNITS: CONTINENTAL BASIN DEPOSITS; CONTINENTAL TERRACE DEPOSITS; AND HOLOCENE ALLUVIUM. THE DISTINCTION IS MADE ACCORDING TO THE AGE AND ORIGIN OF THE MATERIALS, ALTHOUGH SEVERAL INVESTIGATORS (CARDWELL, 1965; FARRAR, JULY 1986) HAVE REPORTED DIFFICULTY IN DIFFERENTIATING BETWEEN THESE UNITS ON THE BASIS OF THE DESCRIPTIONS USUALLY AVAILABLE FROM WELL DRILLERS LOGS. THE AREAL DISTRIBUTION OF THE VALLEY FILL UNITS (CARDWELL, 1965; FARRAR, JULY 1986) IS SHOWN IN FIGURE 5. A SCHEMATIC SECTION THROUGH THE UKIAH VALLEY, ILLUSTRATING THE STRATIGRAPHIC RELATIONSHIP BETWEEN THE VALLEY FILL UNITS, IS SHOWN IN FIGURE 6.

BASED ON STRATIGRAPHIC INFORMATION OBTAINED FROM AVAILABLE WATER WELL LOGS, A REGIONAL GEOLOGIC CROSS-SECTION ALONG THE AXIS OF THE UKIAH VALLEY, PARALLEL TO THE DIRECTION OF GROUND WATER FLOW, HAS BEEN PREPARED. THE APPROXIMATE LOCATIONS OF THE WATER-PRODUCING WELLS, GROUND WATER CONTOURS, AND THE SECTION LINE ARE SHOWN IN FIGURE 4. THE REGIONAL GEOLOGIC CROSS-SECTION IS SHOWN IN FIGURE 7. EACH OF THE THREE VALLEY FILL UNITS REFERENCED ABOVE IS DESCRIBED BELOW AS THEY ARE BELIEVED TO BE THE GEOLOGIC UNITS COST RELEVANT TO THE CWP PROJECT.

4.1.1.1 CONTINENTAL BASIN DEPOSITS

THE CONTINENTAL BASIN DEPOSITS ARE OF PLIOCENE AND PLEISTOCENE AGE AND REPRESENT THE OLDEST OF THE VALLEY FILL UNITS. THE CONTINENTAL BASIN DEPOSITS WERE DEPOSITED UNCONFORMABLY OVER THE BASEMENT ROCKS OF THE FRANCISCAN COMPLEX BY LANDSLIDES AND DEBRIS FLOW FROM THE ADJACENT HIGHLANDS. SUBSEQUENT TO DEPOSITION, THE MATERIALS WERE REWORKED BY GRAVITY AND STREAM PROCESSES.

THE COMPLEX DEPOSITIONAL PROCESS RESULTED IN A HETEROGENEOUS MIXTURE OF LOOSELY CEMENTED GRAVEL, SAND, SILT, AND CLAY. THE PREDOMINANT MATERIAL IS CLAY WHICH OCCURS IN BEDS AND AS INTERSTITIAL MATERIAL BETWEEN COARSER GRAINS OF SAND AND GRAVEL. THE HIGH CLAY CONTENT AND POOR SORTING RESULT IN GENERALLY LOW PERMEABILITIES.

THE THICKNESS OF THE CONTINENTAL BASIN DEPOSITS RANGES FROM ZERO ALONG THE MARGINS OF THE UKIAH VALLEY TO AT LEAST 500 FEET NEAR ITS AXIS. NO OUTCROPS HAVE BEEN RECORDED ALONG THE WESTERN MARGIN OF THE UKIAH VALLEY NEAR THE SITE; HOWEVER, EXTENSIVE OUTCROPS DO OCCUR ALONG THE EASTERN SIDE. REPORTEDLY, THE CONTINENTAL BASIN DEPOSITS ARE LIKELY TO OCCUR AT DEPTH, BENEATH YOUNGER VALLEY FILL DEPOSITS, OVER MOST OF THE UKIAH VALLEY (FARRAR, JULY 1986).

4.1.1.2 CONTINENTAL TERRACE DEPOSITS

THE CONTINENTAL TERRACE DEPOSITS HAVE BEEN SUBDIVIDED (CARDWELL, 1965) INTO OLDER AND YOUNGER TERRACE DEPOSITS. YOUNGER TERRACE DEPOSITS HAVE BEEN MAPPED ALONG THE WESTERN MARGIN OF THE UKIAH VALLEY IN THE VICINITY OF THE SITE. MOST OF THE CITY OF UKIAH, NOTABLY THE DOWNTOWN AREA ALONG STATE STREET, HAS BEEN DEVELOPED ON YOUNGER TERRACE DEPOSITS. THE OCCURRENCE OF THE YOUNGER TERRACE DEPOSITS AT THE SURFACE ALONG THE WESTERN MARGIN OF THE UKIAH VALLEY IS DISCONTINUOUS WHERE ROBINSON CREEK EMERGES FROM THE ADJACENT HIGHLANDS. ALTHOUGH LITHOLOGICALLY VERY SIMILAR TO THE CONTINENTAL BASIN DEPOSITS, THE CLAY AND SILT CONTENT OF THE YOUNGER TERRACES IS GENERALLY LESS. AS IN THE CONTINENTAL BASIN DEPOSITS, VERTICAL AND LATERAL DISCONTINUITY OF INDIVIDUAL BEDS AND LENSES IS COMMON. THE UNIT IS GENERALLY CONSIDERED TO HAVE LOW PERMEABILITY.

THE MAXIMUM THICKNESS OF THE YOUNGER CONTINENTAL TERRACE DEPOSITS IS NOT ACCURATELY KNOWN, AS THEY ARE VERY DIFFICULT TO DIFFERENTIATE FROM THE UNDERLYING CONTINENTAL BASIN DEPOSITS.

4.1.1.3 HOLOCENE ALLUVIUM

THE HOLOCENE ALLUVIUM IS COMPOSED OF UNCEMENTED GRAVEL, SAND, SILT, AND CLAY. THE ALLUVIUM REPORTEDLY COVERS BROAD AREAS OF THE UKIAH VALLEY IN THE VICINITY OF THE SITE (CARDWELL, 1965; FARRAR, JULY 1986). THE ALLUVIUM ALSO EXTENDS INTO SEVERAL SMALLER VALLEYS ASSOCIATED WITH TRIBUTARIES TO THE RUSSIAN RIVER, MOST NOTABLY THE VALLEY ASSOCIATED WITH ROBINSON CREEK. WITHIN THE CENTRAL STRIP OF THE VALLEY, ALONG THE RUSSIAN RIVER, HIGHLY PERMEABLE, LOOSE GRAVEL AND COARSE SAND DEPOSITS HAVE BEEN DEVELOPED. THESE DEPOSITS ARE IN DIRECT HYDRAULIC COMMUNICATION WITH THE SURFACE WATER IN THE RUSSIAN RIVER.

THE THICKNESS OF THE HOLOCENE ALLUVIUM IS NOT ACCURATELY KNOWN, AGAIN BECAUSE DIFFERENTIATION BETWEEN THE HOLOCENE ALLUVIUM AND THE UNDERLYING CONTINENTAL BASIN DEPOSITS IS VERY DIFFICULT. AREAS OF HIGH POROSITY AND PERMEABILITY OCCUR DUE TO THE UNCEMENTED, COARSE-GRAINED NATURE OF LOCALIZED SEDIMENTS. THESE AREAS OF HIGH PERMEABILITY ARE TYPICALLY CLOSE TO THE PRESENT COURSE OF THE RUSSIAN RIVER.

4.1.2 STUDY AREA STRATIGRAPHY

PREVIOUS INVESTIGATIONS BY CONSULTANTS TO CWP (H. ESMAILI & ASSOCIATES, AUGUST 1981; J.H. KLEINFELDER AND ASSOCIATES, NOVEMBER 1982; D'APPOLONIA, MAY 1984; IT CORPORATION, JUNE 1985; GEOSYSTEM, JANUARY 1987) AND BY THE RWQCB HAVE INCLUDED THE INSTALLATION OF OVER 30 GROUND WATER MONITORING WELLS AND THE DRILLING OF NUMEROUS SOIL BORINGS IN THE STUDY AREA. BASED ON THE INFORMATION OBTAINED FROM THE ABOVE REFERENCED INVESTIGATIONS, ATTEMPTS HAVE BEEN MADE TO ASSESS THE STRATIGRAPHY ENCOUNTERED AT THE SITE IN THE CONTEXT OF THE REGIONAL GEOLOGY. CARDWELL (1965) HAS MAPPED THE CONTACT BETWEEN THE YOUNGER CONTINENTAL TERRACE DEPOSITS AND THE HOLOCENE ALLUVIUM AS BISECTING THE CWP SITE AS SHOWN IN FIGURE 5. BASED ON THE STRATIGRAPHIC INFORMATION AVAILABLE FROM THE MAJORITY OF THE BORINGS IN THE STUDY AREA, HOWEVER, IT HAS NOT BEEN POSSIBLE TO DIFFERENTIATE BETWEEN THESE UNITS. AS THE TERRACE DEPOSITS ARE TYPICALLY SLIGHTLY ELEVATED, IT IS POSSIBLE THAT CARDWELL ORIGINALLY MAPPED THE CONTACT BASED ON TOPOGRAPHIC RELIEF. IF SO, THE CONSTRUCTION OF US HIGHWAY 101 AND THE OVERALL DEVELOPMENT OF THE AREA APPEARS TO HAVE OBLITERATED ANY SUCH EVIDENCE OF THIS CONTACT.

BASED UPON A REVIEW OF THE STRATIGRAPHIC LOGS RECORDED DURING THE SITE CHARACTERIZATION STUDIES, IT APPEARS THAT THE MATERIALS ENCOUNTERED IN THE STUDY AREA GENERALLY CORRESPOND WITH THE CONTINENTAL BASIN AND TERRACE DEPOSITS. THE PRESENCE OF ELEVATED TERRACES AND THE INCISED NATURE OF THE RUSSIAN RIVER ARE INDICATIVE OF CHANGES IN STREAM LEVEL, PROBABLY AS A RESULT OF RECENT CONTINUED UPLIFT OF THE REGION. CONSEQUENTLY, EROSIONAL PROCESSES PREDOMINATE OVER DEPOSITIONAL PROCESSES AND THE MORE COARSE-GRAINED, HIGHLY PERMEABLE SEDIMENTS CHARACTERIZED AS HOLOCENE ALLUVIUM MAY BE LIMITED TO A NARROW STRIP ADJACENT TO THE RUSSIAN RIVER CHANNEL. THE RELATIVELY LARGE NUMBER OF SHALLOW, HIGH PRODUCTION WELLS IMMEDIATELY ADJACENT TO THE RUSSIAN RIVER SUPPORTS THIS GEOLOGIC CONCEPTUALIZATION.

THE STRATIGRAPHIC INFORMATION RECORDED ON THE AVAILABLE DRILLING LOGS HAS BEEN USED TO CONSTRUCT SUBSURFACE PROFILES A-A' AND B-B', WHICH ARE SHOWN IN FIGURES 8 AND 9, RESPECTIVELY. AS SHOWN IN THE SUBSURFACE PROFILES, THE STRATIGRAPHY IN THE SITE AREA IS CHARACTERIZED BY NUMEROUS AND ABRUPT LATERAL FACIES CHANGES. THESE CONDITIONS REFLECT A FLUVIAL ENVIRONMENT IN WHICH THE DEPOSITIONAL CONDITIONS WERE CONSTANTLY CHANGING, RANGING FROM A VERY LOW HYDRAULIC ENERGY (DEPOSITION OF SILT AND CLAY) TO HIGH ENERGY (DEPOSITION OF SAND AND GRAVEL). THE STRATIGRAPHY IS, THEREFORE, COMPLEX AND CORRELATION OF THE VARIOUS UNITS IS NOT SELF-EVIDENT. THERE ARE, HOWEVER, GENERAL LITHOLOGIC TRENDS WHICH ARE FUNCTIONAL IN TERMS OF THE HYDROLOGIC BEHAVIOR OF THE SEDIMENTS AND THE MIGRATION OF CHROMIUM. BASED ON THESE TRENDS, FOUR ZONES, ZONES 1 THROUGH 4, HAVE BEEN DEFINED UNDER THE SITE.

ZONE 1 IS THE UPPERMOST OF THE FOUR ZONES. THE STRATIGRAPHIC INFORMATION INDICATES THAT ZONE 1 IS CONTINUOUS THROUGHOUT THE SITE AND IMMEDIATE DOWNGRADIENT VICINITY. ZONE 1 HAS BEEN REWORKED AND GRADED DURING THE DEVELOPMENT OF THE CWP SITE AND THE CONSTRUCTION OF TAYLOR DRIVE AND SEVERAL SURFACE DRAINAGE FEATURES. THE LOWER BOUNDARY OF ZONE 1 IS DEFINED BY A BLUE, CLAYEY SILT/SILTY CLAY, GLEYED HORIZON. ZONE 1 IS UNDERLAIN IN SEQUENCE BY ZONES 2, 3, AND 4.

AS THE MAJORITY OF THE BORINGS DRILLED FOR SOIL SAMPLING AND MONITORING WALL INSTALLATION

PURPOSES WERE RELATIVELY SHALLOW, THE AREAL EXTENT OF ZONE 2 IS LESS WELL DEFINED. THE AVAILABLE INFORMATION, HOWEVER, INDICATES THAT ZONE 2 MAY BE CONTINUOUS FROM WELL CWP-17 ON SITE TO WELL AT-4 OFF SITE (FIGURES 2 AND 8).

LITTLE INFORMATION IS AVAILABLE REGARDING THE CONTINUITY AND AREAL EXTENT OF ZONE 3 AND 4; HOWEVER, IT IS NOTED THAT THEY ARE NOT OF PRIME IMPORTANCE RELATIVE TO THE POSSIBLE MIGRATION OF CHROMIUM IN GROUND WATER. EACH OF ZONES 1 THROUGH 4 IS DESCRIBED BELOW.

4.1.2.1 ZONE 1

ZONE 1 IS CONSIDERED TO EXTEND VERTICALLY FROM THE GROUND SURFACE TO A DEPTH OF APPROXIMATELY 20 FEET. ZONE 1 CONSISTS PRIMARILY OF SILTY CLAY, CLAYEY SILT, AND CLAYEY SAND, WITH MORE PERMEABLE STRINGERS AND LENSES OF SILTY SAND AND GRAVEL. THE SILTY CLAYS AND CLAYEY SILTS ARE GENERALLY STIFF TO VERY STIFF, LOW TO MODERATELY PLASTIC, AND LOCALLY CONTAIN CARBON GRANULES AND HEALED ROOT HOLES. THE COLORS OF THE SOILS IN ZONE 1 HAVE BEEN RECORDED AS YELLOW-BROWN TO MOTTLED GRAY AND BROWN. VARYING AMOUNTS OF VERY SOFT, DEEPLY WEATHERED FRAGMENTS OF SEDIMENTARY ROCKS (PREDOMINANTLY MUDSTONE) ARE PRESENT IN THE CLAY. BASED ON THE GENERALLY VARIEGATED APPEARANCE AND EMBEDDED ROCK FRAGMENTS IN A CLAY MATRIX, IT IS BELIEVED THAT THE CLAY HAS BED DEVELOPED IN SITU FROM THE YOUNGER TERRACE DEPOSITS. STRINGERS OF GRAVEL AND FINE SAND ARE PRESENT IN THE CLAY WHICH YIELD VARYING, BUT GENERALLY LIMITED, QUANTITIES OF WATER. AS SHOWN IN FIGURES 8 AND 9, THE LATERAL CONTINUITY OF THESE STRINGERS IS THOUGHT TO BE LIMITED AS CORRELATION FOR SIGNIFICANT DISTANCES DOES NOT APPEAR TO BE POSSIBLE.

ZONE 1 IS CONSIDERED TO BE THE ZONE MOST IMPACTED BY CHROMIUM COMPOUNDS. THE LATERAL MIGRATION THROUGH THIS ZONE APPEARS TO BE LIMITED TO THE IRREGULAR, MORE PERMEABLE SAND AND GRAVEL LENSES. THE OFF-SITE MIGRATION OF CHROMIUM IN THESE MORE PERMEABLE STRATA HAS BEEN RETARDED BY THE INSTALLATION OF THE SLURRY CUTOFF WALL AND GROUND WATER EXTRACTION FROM WELL HL-7. THE SLURRY CUTOFF WALL REPORTEDLY EXTENDS THROUGHOUT THE FULL DEPTH OF ZONE 1. THE VERTICAL MIGRATION THROUGH THE SOILS WITHIN ZONE 1 IS BELIEVED TO BE VERY SLOW BECAUSE OF THE APPARENT HETEROGENEITY AND DISCONTINUITY OF PERMEABLE LENSES.

THE LOWER BOUNDARY OF ZONE 1 IS CONSIDERED TO BE THE VERY STIFF, BLUE, GLEYED, CLAYEY SILT/SILTY CLAY LAYER WHICH IS TYPICALLY 4 TO 5 FEET THICK. THE GLEYED AND RELATIVELY UNIFORM QUALITY OF THIS STRATUM INDICATES A WELL-WEATHERED (OLDER) DEVELOPMENT AND LOW HYDRAULIC CONDUCTIVITY. AS SHOWN IN FIGURES 8 AND 9, THIS BLUE CLAY/SILT LAYER HAS BEEN INTERCEPTED BY NUMEROUS BORINGS AT THE SITE AND CORRELATES REASONABLY WELL FROM THE CENTER OF THE SITE AS FAR SOUTH AS BORING AT-5. THIS STRATUM IS LESS WELL DEFINED NEAR THE RETORTS; HOWEVER, IT IS NOTED THAT THE TOPOGRAPHY IN THIS AREA IS ELEVATED AND THE BORINGS ARE GENERALLY SHALLOWER. THE BLUE CLAY/SILT LAYER APPEARS TO LIMIT DOWNWARD MIGRATION OF CHROMIUM FROM ZONE 1 TO ZONE 2.

THE CORRELATION OF THIS STRATUM DEPENDS PRIMARILY ON ITS DISTINCTIVE BLUE COLORATION. THE APPARENT ABSENCE OF THIS BLUE CLAY/SILT LAYER IN SOME BORINGS (CWP-13 AND CWP-17) MAY BE ATTRIBUTABLE TO GEOLOGIC CONDITIONS AND/OR TO SAMPLING AND DESCRIPTIVE PROCEDURES, FOR EXAMPLE, AS SHOWN IN PROFILE A-A' (FIGURE 8), THE BLUE CLAY/SILT LAYER WAS ENCOUNTERED IN WELL CWP-22; FURTHER TO THE NORTH, HOWEVER, IN WELL CWP-13, THE FINEGRAINED SEDIMENTS HAVE BEEN REPLACED BY A SANDY FACIES. IT IS POSSIBLE THAT THE BLUE CLAY/SILT LAYER WAS DEPOSITED AND LATER ERODED AND REPLACED BY A CHANNEL-FILL, REPRESENTING A HIGHER ENERGY FACIES. ON THE OTHER HAND, THE OMISSION MAY BE DUE TO THE SAMPLING INTERVAL, AS COMPARED WITH THE THICKNESS OF THE LAYER.

4.1.2.2 ZONE 2

ZONE 2 CONSISTS OF A SAND AND GRAVEL LAYER WHICH VARIES FROM APPROXIMATELY 5 TO 10 FEET THICK. THE SANDS AND GRAVELS IN ZONE 2 GENERALLY CONTAIN APPRECIABLE AMOUNTS OF SILT AND CLAY, AND ARE DENSE AND SLIGHTLY CEMENTED IN SOME AREAS. MOST OF THE GRAVEL IS SUBANGULAR AND LESS THAN ONE-HALF INCH IN SIZE. STRINGERS OF POORLY GRADED FINE SAND AND MEDIUM COARSE SAND ARE ALSO PRESENT. IN BORING AT-4, A THIN LAYER OF SILT IS PRESENT WITHIN ZONE 2.

ZONE 2 IS BELIEVED TO BE THE MOST SIGNIFICANT WATER PRODUCER OF THE FOUR ZONES IN THE SITE AREA. AS SHOWN IN FIGURE 8, ZONE 2 CAN BE CORRELATED BETWEEN THE DEEP BORINGS FROM SOUTH OF THE RETORT AREA TO OFF-SITE AREAS. ZONE 2 APPEARS TO DECREASE IN THICKNESS TO THE SOUTHEAST AND WAS NOT ENCOUNTERED AT ALL IN BORING AT-5. THIS MAY SUGGEST THAT ZONE 2 IS DISCONTINUOUS TO THE SOUTHEAST OR IS CONFINED TO CHANNELS WHICH WERE NOT INTERCEPTED BY BORING AT-5.

4.1.2.3 ZONE 3

ZONE 3 IS CONSIDERED TO BE THE STIFF, OLIVE-BROWN, CLAYEY SILT STRATUM THAT FORMS THE LOWER BOUNDARY OF ZONE 2. ZONE 3 HAS BEEN ENCOUNTERED IN SEVERAL BORINGS, AS SHOWN IN FIGURE 8, AND CAN BE CORRELATED FROM OFF-SITE AREAS AROUND WELL AT-4 TO WELL CWP-13 AT THE SITE. THE THICKNESS OF ZONE 3 APPEARS TO VARY FROM 4 TO 6 FEET. THE LOW PERMEABILITY OF THE SOILS IN ZONE 3 ARE EXPECTED TO SIGNIFICANTLY RESTRICT THE VERTICAL MOVEMENT OF GROUND WATER.

4.1.2.4 ZONE 4

ZONE 4 IS CONSIDERED TO BE THE CLAYEY SAND AND GRAVEL STRATUM WHICH UNDERLIES ZONE 3. AS SHOWN IN FIGURE 8, THIS STRATUM APPEARS TO BE CONTINUOUS FROM THE PEAR ORCHARD TO AT LEAST THE EASTERN BOUNDARY OF THE SITE. THE SPARSITY OF DEEP BORINGS IN THE NORTHERN AND WESTERN PORTIONS OF THE SITE DOES NOT PERMIT FURTHER CORRELATION. IT IS NOTED, HOWEVER, THAT THE PERMEABILITY OF ZONE 4 APPEARS TO INCREASE TO THE SOUTHEAST. IN BORING CWP-13, ZONE 4 IS CHARACTERIZED AS A MEDIUM TO COARSE SAND WITH SOME SILT AND GRAVEL; AND IN BORING AA-5 AS A CLEAN SAND AND SANDY GRAVEL. THE WATER-PRODUCING CHARACTERISTICS OF ZONE 4 VARY ACCORDINGLY.

AN ALTERNATIVE SCENARIO FOR THE VARYING PERMEABILITY IS THAT TO THE NORTHWEST, ZONE 4 REPRESENTS THE TERRACE DEPOSITS DESCRIBED IN SECTION 4.1.1.2. TO THE SOUTHEAST, ZONE 4 MAY REPRESENT THE HOLOCENE ALLUVIUM ASSOCIATED WITH THE RUSSIAN RIVER OR ROBINSON CREEK.

4.2 GROUND WATER HYDROLOGY

THE FOLLOWING SECTIONS PROVIDE A SUMMARY OF GENERAL GROUND WATER CONDITIONS IN THE VALLEY FILL DEPOSITS OF THE UKIAH VALLEY AND A DESCRIPTION OF GROUND WATER OCCURRENCE IN THE STRATA ENCOUNTERED BENEATH THE CWP SITE.

4.2.1 REGIONAL GROUND WATER CONDITIONS

GROUND WATER OCCURS PRIMARILY IN THE VALLEY FILL DEPOSITS IN THE UKIAH VALLEY. IN THE CONTINENTAL BASIN DEPOSITS, GROUND WATER OCCURS UNDER CONFINED CONDITIONS AND WELLS COMPLETED IN THIS UNIT GENERALLY PRODUCE WATER "SLOWLY" BECAUSE OF THE FINE-GRAINED NATURE OF SEDIMENTS. THE SPECIFIC CAPACITIES OF 30 WELLS COMPLETED IN THE CONTINENTAL BASIN DEPOSITS RANGE FROM 0.004 TO 1.33 GALLONS/MINUTE/ FOOT AND "DRY HOLES" ARE NOT UNCOMMON (FARRAR, JULY 1986).

BECAUSE THEY ARE RELATIVELY THIN AND IMPERMEABLE, THE YOUNGER TERRACE DEPOSITS ARE NOT CONSIDERED A MAJOR SOURCE OF GROUND WATER. WELLS COMPLETED IN THE TERRACE DEPOSITS MAY YIELD SUFFICIENT WATER FOR LOW-CAPACITY DOMESTIC OR STOCK-WATERING WELLS. SPECIFIC CAPACITIES OF WELLS COMPLETED IN THE TERRACE DEPOSITS RANGE FROM 0.02 TO 7.1 GALLONS/MINUTE/FOOT AND FLUCTUATIONS IN THE WATER TABLE CAN "DRASTICALLY" AFFECT WELL PERFORMANCE (FARRAR, JULY 1986).

THE HOLOCENE ALLUVIUM IS CONSIDERED THE MOST PRODUCTIVE WATERBEARING UNIT IN THE UKIAH VALLEY AND PROVIDES "SUFFICIENT WATER FOR SUSTAINED PUMPAGE FOR MUNICIPAL AND IRRIGATION WELLS." THE MORE PERMEABLE, COARSER-GRAINED SEDIMENTS APPEAR TO BE LOCATED ALONG THE PRESENT COURSE OF THE RUSSIAN RIVER, AS EVIDENCED BY SEVERAL HIGH-PRODUCTION WELLS. THESE INCLUDE COMMUNITY WATER SUPPLY WELLS OPERATED BY THE WILLOW COUNTY WATER DISTRICT (WCWD), INCLUDING WELLS 14N/L2W-9AL AND -9A2 AND WELLS 15N/12W-33E3, -33E4, -33E5, AND -33E6. THE LOCATIONS OF THESE WELLS ARE SHOWN IN FIGURE 4. ALSO, A SERIES OF WELLS HAS BEEN INSTALLED ALONG THE WESTERN BANK OF THE RUSSIAN RIVER FROM SOUTH OF THE UKIAH SEWAGE DISPOSAL FACILITY TO THE EL ROBLES RANCH. THIS SERIES OF WELLS, SHOWN IN FIGURE 4, INCLUDES WELLS 14N/12W-4B, -4G, -4J, -4R1, AND -4R2. THESE WELLS SUPPLY WATER FOR IRRIGATION AND ARE BELIEVED TO DERIVE A PORTION OF THEIR PRODUCTION FROM SURFACE WATER IN THE RUSSIAN RIVER, INDUCED TO FLOW THROUGH PERMEABLE ALLUVIAL DEPOSITS AS THE GROUND WATER LEVEL IS LOWERED BY PUMPING. IT HAS BEEN REPORTED (FARRAR, JULY 1986) THAT UNDER MOST FLOW CONDITIONS, GROUND WATER MOVES FROM THE ALLUVIUM INTO THE RUSSIAN RIVER. DURING PERIODS OF HIGH WATER LEVELS IN THE RUSSIAN RIVER, HOWEVER, THE REVERSE SITUATION OCCURS.

ON A REGIONAL BASIS, GROUND WATER IN THE VALLEY FILL DEPOSITS FLOWS APPROXIMATELY NORTH TO SOUTH ALONG THE AXIS OF THE UKIAH VALLEY. NEAR THE WEST MARGIN OF THE VALLEY, HOWEVER, GROUND WATER GENERALLY FLOWS TO THE EAST, FOLLOWING THE TOPOGRAPHY. REGIONAL GROUND WATER CONTOURS ARE SHOWN IN FIGURE 4.

4.2.2 STUDY AREA GROUND WATER

IN THE STUDY AREA, GROUND WATER OCCURS PRIMARILY IN STRATIGRAPHIC ZONES 1 AND 2. THE FOLLOWING DISCUSSION FOCUSES ON THESE STRATA, AS THEY ARE OF PRIMARY CONCERN REGARDING THE MIGRATION OF CHROMIUM.

THE GROUND WATER FLOW" DIRECTION AND HYDRAULIC GRADIENT HAVE BEEN ESTABLISHED FROM WATER LEVEL DATA ACCUMULATED THROUGHOUT THE INVESTIGATIONS PERFORMED AT THE SITE. THESE DATA ARE SUMMARIZED IN TABLE B.L OF APPENDIX B. BASED ON WATER LEVEL MEASUREMENTS IN MONITORING WELLS COMPLETED IN ZONE 1, MADE BY CWP PERSONNEL IN JANUARY 1987, ZONE 1 GROUND WATER CONTOURS HAVE BEEN GENERATED. THESE ZONE 1 CONTOURS ARE SHOWN IN FIGURE 10. THE ZONE 1 GROUND WATER CONTOURS INDICATE AN OVERALL SOUTHEASTERLY DIRECTION OF FLOW WITH A HYDRAULIC GRADIENT OF ABOUT 0.005. THIS IS CONSISTENT WITH THE DIRECTION OF REGIONAL GROUND WATER FLOW SHOWN IN FIGURE 4. IN OFF-SITE AREAS TO THE SOUTHEAST OF THE SITE, THE CONTOURS INDICATE A FLOW DIRECTION TO THE SOUTH WITH APPROXIMATELY THE SAME HYDRAULIC GRADIENT.

AS SHOWN IN TABLE 1, THERE ARE ONLY THREE GROUND WATER MONITORING WELLS, WELLS CWP-15, CWP-22, AND AT-4, COMPLETED EXCLUSIVELY IN ZONE 2. THESE THREE DATA POINTS ARE NOT SUFFICIENT TO GENERATE GROUND WATER CONTOURS IN ZONE 2. COMPARISON OF THE GROUND WATER LEVELS IN WELLS CWP-18, CWP-22, AND AT-4 WITH THOSE IN ADJACENT ZONE 1 MONITORING WELLS, HOWEVER, INDICATES THAT THE ZONE 2 WATER LEVELS ARE APPROXIMATELY 1 FOOT BELOW THOSE IN ZONE 1. SEVERAL OTHER WELLS (WELLS CWP-7, CWP-8, CWP-9, CWP-14, AND CWP-19) ARE COMPLETED IN ZONES 1 AND 2. THE WATER LEVELS IN THESE WELLS GENERALLY APPEAR TO REFLECT ZONE 1 GROUND WATER LEVELS.

THE HYDRAULIC PROPERTIES OF THE WATER-BEARING ZONES HAVE BEEN INVESTIGATED BY PREVIOUS CONSULTANTS AND GEOSYSTEM BY MEANS OF SEVERAL PUMPING AND SLUG TESTS (GEOSYSTEM, MARCH 1986). THE DATA COLLECTED THROUGHOUT THESE INVESTIGATIONS HAVE BEEN SUMMARIZED BY GEOSYSTEM (SEPTEMBER 19, 1986). THESE DATA SUGGEST THAT HYDRAULIC CONDUCTIVITIES OF ZONES I AND 2 ARE GENERALLY ON THE ORDER OF (10-3) TO (10-2) CM/SEC. ZONES 3 AND 4 WERE CONSIDERED TO HAVE LOWER PERMEABILITY; HOWEVER, MORE RECENT STRATIGRAPHIC DATA (GEOSYSTEM, JANUARY 1987) SUGGEST THAT ZONE MAY BE HIGHLY PERMEABLE TO THE SOUTHEAST OF THE SITE. ZONES 3 AND 4 ARE OF LESS IMPORTANCE TO THE REMEDIATION OF CHROMIUM IN OFF-SITE AREAS. A SUMMARY OF THE HYDRAULIC PROPERTIES OF ZONE 1 IS PRESENTED IN TABLE 5 AND A SUMMARY OF THE HYDRAULIC CONDUCTIVITY DATA OBTAINED BY FIELD TESTS THROUGHOUT THE COURSE OF THE SITE CHARACTERIZATION STUDIES IS PRESENTED IN TABLE 6.

4.3 SURFACE WATER HYDROLOGY

THE RUSSIAN RIVER, WHICH ORIGINATES IN CENTRAL MENDOCINO COUNTY AND FLOWS SOUTH TO SONOMA COAST STATE BEACH, IS THE MOST IMPORTANT SURFACE DRAINAGE SYSTEM IN THE UKIAH VALLEY. AT ITS CLOSEST POINT, THE RUSSIAN RIVER FLOWS APPROXIMATELY 2,000 FEET TO THE EAST OF THE CWP SITE. FLOW IN THE RUSSIAN RIVER IS REGULATED BY CONTROLLING THE CONTRIBUTIONS FROM SEVERAL OF ITS MAJOR TRIBUTARIES. MINIMUM FLOWS ARE REQUIRED TO BE MAINTAINED, HOWEVER, AT VARIOUS LOCATIONS ON THE RUSSIAN RIVER. ONE OF THESE LOCATIONS IS AT THE JUNCTION OF THE EAST AND WEST FORKS OF THE RUSSIAN RIVER JUST NORTH OF UKIAH. AT THIS POINT, A MINIMUM FLOW OF APPROXIMATELY 150 CFS IS REQUIRED (DWR, MAY 1980). THE RUSSIAN RIVER HAS NUMEROUS BENEFICIAL USES, AS DESCRIBED IN SECTION 4.4.1.

TRIBUTARIES TO THE RUSSIAN RIVER INCLUDE NUMEROUS SMALL STREAMS ISSUING FROM THE MOUNTAINS THAT BORDER THE UKIAH VALLEY TO THE EAST AND WEST. THE MOST SIGNIFICANT OF THESE TRIBUTARIES IN THE VICINITY OF THE CWP SITE IS ROBINSON CREEK, WHICH MERGES WITH THE RUSSIAN RIVER AT A POINT ABOUT 4,500 FEET TO THE SOUTHEAST. THE LOCATIONS OF THE RUSSIAN RIVER AND ROBINSON CREEK, RELATIVE TO THE CWP SITE, ARE SHOWN IN FIGURE 1.

FLOW IN ROBINSON CREEK OCCURS ESSENTIALLY YEAR ROUND AND FOLLOWS THE NATURAL DRAINAGE COURSE. OTHER, SMALLER SURFACE DRAINAGE FEATURES FLOW ONLY WHEN PRECIPITATION OCCURS IN THE UKIAH VALLEY OR THE ADJACENT HIGHLANDS RESERVATIONS BY CWP PERSONNEL INDICATE THAT, DEPENDING ON THE INTENSITY AND DURATION OF THE RAINFALL, FLOW IN THESE SMALLER SURFACE DRAINAGE FEATURES MAY REACH THE RUSSIAN RIVER OR PERCOLATE INTO THE VALLEY FILL PRIOR TO REACHING THE RIVER. DURING THE WINTER MONTHS, WHEN THE WATER TABLE RISES TO WITHIN 2 OR 3 FEET OF THE LAND SURFACE, GROUND WATER MAY FLOW INTO THE LOW-LYING SURFACE DRAINAGE DITCHES. UNDER THESE CIRCUMSTANCES, WATER WOULD BE PRESENT IN THE DITCHES EVEN WHEN NO PRECIPITATION IS OCCURRING. SUCH WATER WOULD NOT, HOWEVER, BE REPRESENTATIVE OF STORM WATER RUNOFF ORIGINATING FROM THE CWP SITE.

FLOW IN THE MAJORITY OF THESE SMALLER SURFACE DRAINAGE FEATURES IS INTERMITTENT AND IS CONTROLLED AND DIVERTED BY CULVERTS AND DITCHES. SEVERAL SMALL DITCHES AND CULVERTS DIVERT

SURFACE WATER RUNOFF AROUND AND BENEATH THE CWP SITE. THE LOCATIONS OF THE DITCHES AND CULVERTS IN THE IMMEDIATE VICINITY OF THE SITE ARE SHOWN IN FIGURE 2. THE DITCHES THAT FLOW BENEATH AND AROUND THE CWP SITE REPORT TO A COMMON DITCH THAT FLOWS SOUTH, PARALLEL TO AND EAST OF TAYLOR DRIVE. THIS COMMON DITCH FLOWS EAST ALONG THE NORTHERN BOUNDARY OF THE ALEX THOMAS PEAR ORCHARD AND BENDS SOUTH ALONG THE RAILROAD TRACKS. FLOW IN THE DITCH, BY NOW AUGMENTED BY RUNOFF FROM THE PEAR ORCHARD AND THE RAILROAD CORRIDOR, ENTERS AN EAST-WEST LATERAL DRAIN WHICH DISCHARGES TO THE RUSSIAN RIVER. IT WAS OBSERVED IN OCTOBER 1987, THAT THE LATERAL DITCH CONTAINED SMALL AMOUNTS OF WATER; HOWEVER, THE OTHER TRIBUTARY DITCHES WERE DRY.

SURFACE WATER QUALITY IN THE RUSSIAN RIVER IS CONSIDERED TO BE OF "EXCELLENT TO GOOD QUALITY" IN TERMS OF MINERAL CONTENT (DWR, MAY 1980). USING ELECTRICAL CONDUCTIVITY (EC) AS AN INDICATOR OF MINERAL CONTENT, WATER QUALITY STANDARDS RECOMMEND AN EC OF LESS THAN 450 MICROMHOS. THE AVERAGE EC OF RUSSIAN RIVER WATER, BETWEEN POTTER VALLEY TO THE NORTH OF UKIAH AND HOPLAND TO THE SOUTH, RANGES FROM 140 TO 190 MICROMHOS. THE AVERAGE HARDNESS IS 115 MG/L (AS CACO3), WHICH IS CONSIDERED TO BE MODERATELY HARD AND NOT LIKELY TO ADVERSELY AFFECT MOST BENEFICIAL USES (DWR, MAY 1980). HIGH, NON-ORGANIC TURBIDITY IS AN OCCASIONAL PROBLEM IN THE RUSSIAN RIVER AND ITS TRIBUTARIES DURING PERIODS OF PROLONGED RAINFALL AND RELEASE OF WATER FROM LAKE MENDOCINO. THIS TURBIDITY MAY ALSO BE AGGRAVATED BY THE REMOVAL OF GRAVEL FOR USE IN CONSTRUCTION, AS THE DISTURBED RIVER CHANNEL CAN CONTRIBUTE SIGNIFICANT TURBIDITY TO WATER IN THE RUSSIAN RIVER.

4.4 BENEFICIAL USES OF WATER

THIS SECTION SUMMARIZES THE KNOWN BENEFICIAL USES OF SURFACE AND GROUND WATER IN THE UKIAH VALLEY IN THE VICINITY OF THE CWP SITE. THE BENEFICIAL USES OF SURFACE AND GROUND WATER HAVE BEEN SUMMARIZED PRIMARILY FROM AVAILABLE REPORTS PUBLISHED BY VARIOUS STATE GOVERNMENT AGENCIES. THE SOURCES OF INFORMATION ARE REFERENCED AS APPROPRIATE. AN INVENTORY OF WATER-PRODUCING WELLS IN THE VICINITY OF THE SITE HAS ALSO BEEN PERFORMED. IN ADDITION TO AIDING ASSESSMENT OF THE BENEFICIAL USES OF GROUND WATER, THE PURPOSE OF THE WELL INVENTORY WAS TO IDENTIFY AND LOCATE WELLS IN THE VICINITY OF THE SITE AND DOCUMENT WELL CONSTRUCTION DETAILS.

FOR THE PURPOSE OF THIS DISCUSSION, AND TO MAINTAIN CONSISTENCY WITH DWR WATER SUPPLY ASSESSMENT PROCEDURES, SURFACE WATER IS CONSIDERED TO BE "WATER FLOWING IN THE VARIOUS STREAM COURSES PLUS UNDERFLOW. UNDERFLOW MAY BE DEFINED AS SUBSURFACE WATER CONTAINED IN THE CHANNEL DEPOSITS, WHICH IF EXTRACTED, WOULD AFFECT STREAM FLOW WITHIN A SHORT PERIOD OF TIME" (DWR, MAY 1980). IT IS NOT UNCOMMON TO INSTALL WELLS IN THE COARSE, STREAM CHANNEL DEPOSITS IMMEDIATELY ADJACENT TO THE RUSSIAN RIVER AND EXTRACT UNDERFLOW. AS THE UNDERFLOW AND SURFACE WATERS ARE IN DIRECT HYDRAULIC COMMUNICATION, EXTRACTED UNDERFLOW IS CONSIDERED TO BE SURFACE WATER.

4.4.1 SURFACE WATER

THE RUSSIAN RIVER IS A MAJOR MUNICIPAL WATER SUPPLY FOR MENDOCINO, SONOMA, AND MARIN COUNTIES. IN ADDITION TO MUNICIPAL SUPPLY, WATER FROM THE RUSSIAN RIVER IS USED FOR AGRICULTURAL, INDUSTRIAL, AND RECREATIONAL PURPOSES.

ACCORDING TO THE WATER QUALITY CONTROL PLAN FOR THE NORTH COASTAL BASIN, THE SPECIFIC BENEFICIAL USES OF THE RUSSIAN RIVER INCLUDE:

- MUNICIPAL AND DOMESTIC SUPPLY
- AGRICULTURAL SUPPLY
- INDUSTRIAL SERVICE SUPPLY
- INDUSTRIAL PROCESS SUPPLY
- GROUND WATER RECHARGE
- NAVIGATION
- POTENTIAL HYDROPOWER GENERATION
- CONTACT WATER RECREATION
- NON-CONTACT WATER RECREATION
- WARM FRESHWATER HABITAT
- WILDLIFE HABITAT
- FISH MIGRATION
- FISH SPAWNING.

OTHER THAN CONTRIBUTING TO THE RUSSIAN RIVER, LITTLE INFORMATION IS AVAILABLE REGARDING DIRECT BENEFICIAL USES OF THE NUMEROUS SMALL TRIBUTARY STREAMS. THE BENEFICIAL USES OF WATER IN THE

TRIBUTARY DITCHES FLOWING AROUND THE CWP SITE, HOWEVER, INCLUDE WILDLIFE HABITAT AND, DURING PORTIONS OF THE YEAR, FRESHWATER HABITAT. IN ADDITION, GROUND WATER RECHARGE IS A BENEFICIAL USE OF THE WATER IN THESE TRIBUTARIES.

THE APPROXIMATE VOLUME OF SURFACE WATER FOR AGRICULTURAL AND URBAN USE IN 1975 WAS ESTIMATED TO BE 10,600 AND 6,000 ACRE-FEET, RESPECTIVELY. THE DEMAND ON SURFACE WATER RESOURCES IS PROJECTED TO INCREASE TO ABOUT 14,200 AND 6,800 ACRE-FEET FOR AGRICULTURAL AND URBAN USE, RESPECTIVELY, BY THE YEAR 2000 (DWR, MAY 1980).

4.4.2 GROUND WATER

BENEFICIAL USE OF THE GROUND WATER RESOURCES IN THE VICINITY OF THE CWP SITE INCLUDE PRIMARILY COMMUNITY WATER SUPPLY, DOMESTIC WATER SUPPLY, AND IRRIGATED AGRICULTURE.

IN GENERAL, WELL LOCATION AND THE PARTICULAR UNIT OF THE VALLEY FILL IN WHICH A WELL IS COMPLETED INFLUENCE YIELD AND THE BENEFICIAL USE OF THE EXTRACTED WATER. WELLS COMPLETED IN THE CONTINENTAL BASIN AND TERRACE DEPOSITS GENERALLY YIELD GROUND WATER IN AMOUNTS SUITABLE ONLY FOR LOW-CAPACITY DOMESTIC WELLS, STOCK-WATERING WELLS, OR LIMITED IRRIGATION WELLS (FARRAR, JULY 1986). WELLS COMPLETED IN THE HOLOCENE ALLUVIUM CAN YIELD SUFFICIENT WATER UNDER SUSTAINED PUMPING FOR MUNICIPAL AND IRRIGATION SUPPLY. WCWD EXTRACTS GROUND WATER FROM WELLS LOCATED IN THE NORGARD LANE WELL FIELD, APPROXIMATELY 2,200 FEET NORTH OF THE CWP SITE, AND FROM TWO WELLS NEAR THE RUSSIAN RIVER, APPROXIMATELY 8,000 FEET SOUTH OF THE CWP SITE.

4.5 SOIL, STORM WATER, AND GROUND WATER QUALITY

THIS SECTION PRESENTS THE DISTRIBUTION AND OCCURRENCE OF CHROMIUM AND OTHER INDICATOR PARAMETERS IN SOIL, STORM WATER, AND GROUND WATER IN THE STUDY AREA. THROUGHOUT THE REMAINDER OF THIS REPORT, HEXAVALENT CHROMIUM IS REFERRED TO AS CR(VI) AND TRIVALENT CHROMIUM IS REFERRED TO AS CR (III). UNLESS SPECIFIED OTHERWISE, CHROMIUM REFERS TO TOTAL CHROMIUM. WATER AND SOIL QUALITY DATA HAVE BEEN GENERATED OVER SEVERAL YEARS OF SITE CHARACTERIZATION STUDIES AND MONITORING. GROUND WATER, STORM WATER, AND SOIL QUALITY DATA ARE CONTAINED IN APPENDICES B, C, AND D, RESPECTIVELY, AND ARE SUMMARIZED IN THE FOLLOWING SECTIONS.

4.5.1 DISTRIBUTION OF CHROMIUM, ARSENIC, AND COPPER IN SOIL

A TOTAL OF 26 SOIL BORINGS (BORINGS S-1 THROUGH S-26) WERE DRILLED (D'APPOLONIA/IT CORPORATION, MAY 1984) IN THE STUDY AREA TO ASSESS THE AREAL EXTENT OF CHROMIUM, ARSENIC, AND COPPER IN SOIL GO A DEPTH OF ABOUT 20 FEET. SOIL SAMPLES WERE COLLECTED AT DEPTHS OF 1, 3, 6, 10, IS, AND 20 FEET. NEAR-SURFACE SOIL SAMPLES FROM DEPTHS OF 1 AND 2 FEET WERE ALSO COLLECTED FROM 17 OTHER LOCATIONS (G-1 THROUGH G-17) TO FURTHER DELINEATE THE AREAL DISTRIBUTION OF CHEMICALS IN NEAR-SURFACE SOILS. THE LOCATIONS OF THE SOIL SAMPLING STATIONS ARE SHOWN IN FIGURE 11. ALL SOIL SAMPLES WERE ANALYZED FOR TOTAL OR HEXAVALENT CHROMIUM, ARSENIC, AND COPPER. A SUMMARY OF THE DATA IS PRESENTED IN TABLES D.1 THROUGH D.4 OF APPENDIX D. PLOTS OF CHROMIUM CONCENTRATIONS WITH DEPTH FOR SELECTED BORINGS ARE ALSO INCLUDED IN APPENDIX D. ALL CONCENTRATIONS REFLECT THE TOTAL QUANTITY OF THE METALS PRESENT IN THE SAMPLES. THE SAMPLE ID PROVIDES A DESIGNATION FOR EITHER A BORING (5) OR A SURFACE SAMPLE (G), FOLLOWED BY A NUMBER IDENTIFYING THE LOCATION. THE LAST NUMBER IN THE DESIGNATION IDENTIFIES THE DEPTH AT WHICH THE SAMPLE WAS COLLECTED. FROM A GENERAL REVIEW OF THE DATA, THE FOLLOWING OBSERVATIONS CAN BE MADE:

- ELEVATED CHROMIUM CONCENTRATIONS EXIST IN THE UPPER 3 FEET OF SOIL AND ESPECIALLY IN THE TOP 1 FOOT (G10, 1'; S-4, 1'; S-8, 0'; S-5, 0")
- CHROMIUM CONCENTRATIONS IN SAMPLES COLLECTED FROM MORE THAN 3 FEET BELOW THE SURFACE ARE GENERALLY LOWER THAN 50 MG/KG IN ALL BORINGS, EXCEPT IN 5-8 AT THE 10-FOOT DEPTH AND 5-10 AT THE 15-FOOT DEPTH.
- CHROMIUM CONCENTRATIONS ARE HIGHER IN BORINGS NEAR THE RETORT AND SUMP AREAS.
- THE MAXIMUM DETECTED CONCENTRATIONS OF CHROMIUM, COPPER, AND ARSENIC IN SURFICIAL SOILS ARE 540, 230 AND 220 MG/KG, RESPECTIVELY (APPENDIX D).
- GENERALLY, THERE APPEARS TO BE GOOD CORRELATION BETWEEN CHROMIUM, ARSENIC, AND COPPER CONCENTRATIONS.

IN ORDER TO COMPARE BACKGROUND CHROMIUM CONCENTRATIONS IN AREAS NOT AFFECTED BY CWP OPERATIONS, WITH AREAS THAT ARE POSSIBLY IMPACTED BY WOOD PRESERVING OPERATIONS, THE DATA FOR BORINGS S-1 (UPGRADIENT), 6 (BACKGROUND), S-5, S-8, S-10 (RETORT AND SUMP AREA), S-15, S-22, AND S-25 (DOWNGRADIENT) HAVE BEEN SUMMARIZED IN TABLE D-4 (APPENDIX D). BORING S-8 IS LOCATED AT THE EASTERN END OF THE RAIL LINES AND BORING S-10 IS THE CLOSEST BORING TOPOGRAPHICALLY DOWNGRADIENT OF THE RETORTS. IT SHOULD BE NOTED THAT NO SAMPLES HAVE BEEN COLLECTED FROM UNDER THE RETORT/PROCESS AREA. SAMPLING IN THESE AREAS IS NOT POSSIBLE DURING NORMAL FACILITY OPERATION. THE SALIENT FEATURES OF THE DATA INCLUDE THE FOLLOWING:

- HIGHER CHROMIUM CONCENTRATIONS ARE OBSERVED IN THE SURFACE SAMPLES NEAR THE RETORT AND SUMP AREAS.

- CHROMIUM CONCENTRATIONS IN BORING S-1 (UPGRADIENT) SAMPLES COLLECTED BELOW THE 3-FOOT DEPTH ARE GENERALLY IN THE SAME RANGE AS THOSE OBSERVED IN OTHER BORINGS.

- THE BACKGROUND AND UPGRADIENT CONCENTRATIONS OF CHROMIUM, ARSENIC, AND COPPER IN BORINGS S-26 AND S-1 SAMPLES ARE GENERALLY LESS THAN 50 /KG, LESS THAT 14 MG/KG, AND LESS THAN 20 MG/KG, RESPECTIVELY.

SOIL SAMPLES CONTAINING CHROMIUM CONCENTRATIONS GREATER THAN 100 MG/KG WERE SELECTED TO REPRESENT SURFACE SOILS WITH DEFINITE CHROMIUM CONTAMINATION. THE APPROXIMATE AREA OF SUCH CONTAMINATION IS SHOWN IN FIGURE 11. THE MAJORITY OF THE SURFACE SOILS CONTAINING ELEVATED CHROMIUM CONCENTRATIONS ARE IN THE AREA AROUND THE RETORT AND SUMP UNITS WHERE FRESHLY TREATED WOOD HAS BEEN STORED. A NARROW BAND OF SURFACE SOILS WITH APPROXIMATELY 100 MG/KG OR CHROMIUM IS PRESENT TO THE SOUTH OF THE RETORT CHAMBERS. THE AREAL EXTENT OF ELEVATED ARSENIC CONCENTRATIONS IN THE NEAR-SURFACE SOILS IS SIMILAR TO CHROMIUM DISTRIBUTION EXCEPT IN ISOLATED AREAS WITH NEAR BACKGROUND CONCENTRATIONS (C-3, C-7, C-8). THE APPROXIMATE AREAS ENCOMPASSING GREATER THAN 14 MG/KG ARSENIC CONCENTRATION ARE SHOWN IN FIGURE 11.

4.5.2 STORM WATER QUALITY

THIS SECTION SUMMARIZES THE AVAILABLE WATER QUALITY DATA OBTAINED FROM STORM WATER SAMPLES COLLECTED AT THE CWP SITE. FLOW IN THE DITCHES AND CULVERTS AROUND AND BENEATH THE CWP SITE OCCURS AS A RESULT OF PRECIPITATION IN THE UKIAH VALLEY OR THE ADJACENT HIGHLANDS. AS NOTED IN SECTION 4.3, GROUND WATER MAY BE PRESENT IN LOW-LYING DRAINAGE DITCHES ON A CONTINUOUS BASIS DURING THE WINTER MONTHS. A DIFFERENTIATION IS MADE, HOWEVER, BETWEEN THIS WATER AND STORM WATER RUNOFF.

A SURFACE OR STORM WATER MONITORING PROGRAM IS IN EFFECT AT THE SITE AND SEVERAL STORM WATER MONITORING LOCATIONS HAVE BEEN ESTABLISHED. CURRENTLY, THE STORM WATER MONITORING PROGRAM INCLUDES COLLECTION OF SAMPLES FROM STATIONS NE, NW, AND C-100. UP UNTIL DECEMBER 1984, STATIONS SE AND SW WERE ALSO MONITORED. THE LOCATIONS OF THESE STATIONS ARE SHOWN IN FIGURE 2. PRIOR TO INSTITUTING SURFACE WATER FLOW CONTROL AT THE CWP SITE, STORM WATER SAMPLES WERE PERIODICALLY COLLECTED AND ANALYZED. RWQCB STAFF HAVE INDICATED THAT THE MEASURED CONCENTRATIONS OF METALS IN 1980 AND 1981 WERE MUCH HIGHER THAN IN SUBSEQUENT YEARS.

MONITORING STATION NW IS LOCATED AT THE ENTRANCE TO THE CULVERT THAT CONDUCTS STORM WATER UNDER THE CWP SITE FROM THE WEST SIDE OF US HIGHWAY 101. THE WATER QUALITY DATA COLLECTED AT THIS LOCATION IS CONSIDERED TO REPRESENT UPGRADIENT OR BACKGROUND CONDITIONS.

MONITORING STATION NE IS LOCATED ON TAYLOR DRIVE AT THE CONFLUENCE OF THE ABOVE-MENTIONED CULVERT AND THE DITCH AROUND THE NORTHEASTERN PORTION OF THE PERIMETER OF THE CWP SITE. DATA COLLECTED AT THIS LOCATION PROVIDE AN INDICATION OF THE QUALITY OF SURFACE RUNOFF FROM THE NORTHERN PORTION OF THE CWP SITE. IT IS NOTED, HOWEVER, THAT ASPHALT BERMS HAVE BEEN CONSTRUCTED TO DIVERT SURFACE RUNOFF FROM TREATED WOOD STORAGE AREAS TO A COLLECTION SUMP. FROM THIS SUMP, THE WATER IS RECYCLED INTO CWP'S WOOD PRESERVING OPERATIONS.

MONITORING STATION C-100 IS LOCATED APPROXIMATELY 100 FEET DOWNSTREAM OF THE CONFLUENCE OF FLOW PASSING FROM STATION NE AND THAT FLOWING BENEATH THE CWP SITE THROUGH A SECOND CULVERT NEAR THE SOUTHERN SITE BOUNDARY. COMPARISON OF DATA COLLECTED FROM THIS LOCATION WITH THAT FROM MONITORING STATION PROVIDES AN INDICATION OF THE OVERALL IMPACT OF SURFACE RUNOFF FROM THE CWP SITE ON STORM WATER QUALITY.

IT IS NOTED THAT AREAS OTHER THAN THE CWP SITE ALSO CONTRIBUTE TO FLOW AT ALL THREE STORM WATER MONITORING STATIONS. THE POSSIBLE IMPACT OF THESE CONTRIBUTIONS MUST BE CONSIDERED WHEN EVALUATING STORM WATER QUALITY.

STORM WATER SAMPLES ARE CURRENTLY ANALYZED FOR DISSOLVED TOTAL CHROMIUM AND ARSENIC; HOWEVER, IN THE PAST, ANALYSES FOR DISSOLVED CR(VI) AND COPPER HAVE ALSO BEEN PERFORMED. THE MOST RECENT AND COMPREHENSIVE DATA, REPRESENTING JANUARY 1988, ARE PRESENTED IN TABLE 7. THE HISTORICAL STORM WATER QUALITY DATA ARE SUMMARIZED IN APPENDIX C. THE DATA INDICATE THAT CHROMIUM, ARSENIC, AND COPPER ARE OCCASIONALLY PRESENT AT DETECTABLE CONCENTRATIONS IN STORM WATER FLOW SAMPLED AT STATIONS NE AND C-100. IT IS NOTED, HOWEVER, THAT THE MEASURED CONCENTRATIONS ARE TYPICALLY CLOSE TO THE DETECTION LIMITS AND THE CONCENTRATION OF CR(VI) HAS OCCASIONALLY EXCEEDED THE DRINKING WATER STANDARD OF 0.05 MG/1 WITHIN THE LAST FIVE YEARS. CHROMIUM, ARSENIC, AND COPPER CONCENTRATIONS IN SAMPLES COLLECTED FROM MONITORING STATION HAVE BEEN AT OR BELOW DETECTION LIMITS SINCE 1983, WITH THE EXCEPTION OF ARSENIC WHICH WAS MEASURED AT 0.006 MG/L IN JANUARY 1986 AT STATION NW. THE MOST RECENT DATA, REPRESENTING APRIL 1988, SHOW NON-DETECTABLE CONCENTRATIONS OF CHROMIUM AND ARSENIC IN MONITORING STATIONS C-100,NE, AND NW.

IN ADDITION TO CWP'S MONITORING, THE RWQCB STAFF HAVE OBTAINED STORM WATER SAMPLES SINCE 1984 WHICH HAVE BEEN ANALYZED FOR CR(III), CR(VI), ARSENIC, AND COPPER. THE POTENTIAL IMPACT FROM PAST AND CURRENT DISCHARGES ARE DISCUSSED IN SECTION 6.0.

4.5.3 GROUND WATER QUALITY

GROUND WATER QUALITY MONITORING HAS BEEN PERFORMED AT THE CWP SITE SINCE 1981. THE CHEMICAL ANALYSES HAVE GENERALLY INCLUDED TOTAL DISSOLVED CHROMIUM, ARSENIC, AND COPPER WITH OCCASIONAL MEASUREMENTS OF DISSOLVED CR (VI). THE COMPREHENSIVE GROUND WATER QUALITY DATA, REPRESENTING JANUARY 1988 CONDITIONS, ARE PRESENTED IN TABLE 7. ALL HISTORICAL GROUND WATER QUALITY DATA HAVE BEEN SUMMARIZED IN TABLE B.2 OF APPENDIX B. THE WATER QUALITY DATA INDICATE THAT:

- THE WELLS COMPLETED IN ZONE 1 NEAR THE RETORT AREA GENERALLY EXHIBIT HIGHER CHROMIUM CONCENTRATIONS AND THE CONCENTRATIONS DECREASE HYDRAULICALLY DOWNGRADIENT.
- THE MAXIMUM DETECTED CONCENTRATIONS OF TOTAL CHROMIUM AND HEXAVALENT CHROMIUM IN GROUND WATER OCCURRED IN WELL CWP-6 AT 125 AND 78 MG/L, RESPECTIVELY.
- CHROMIUM CONCENTRATIONS HAVE GENERALLY DECREASED WITH TIME. WELLS CWP-2A, CWP-2B, CWP-6 (NEAR RETORT AREA), CWP-8, CWP-11 (NEAR SITE BOUNDARY), AND FPT-3, FPT-4, FPT-5, AT-1 (OFF SITE) SUPPORT THIS OBSERVATION.
- THE CONCENTRATIONS OF CHROMIUM IN ON-SITE WELLS COMPLETED IN ZONE 2 ARE NOT SIGNIFICANT AND MAY RESULT FROM LIMITED COMMUNICATION WITH ZONE 1.
- ZONE 2 DOES NOT CONTAIN ELEVATED CHROMIUM CONCENTRATIONS IN OFF-SITE AREAS.
- ZONE 2 AND 4 DO NOT APPEAR TO BE IMPACTED BY THE PRESENCE OF CHROMIUM.

SELECTED GROUND WATER QUALITY DATA HAVE BEEN USED TO GENERATE CHROMIUM ISOCONCENTRATIONS TO PROVIDE AN AREAL REPRESENTATION OF THE CHROMIUM PLUME IN GROUND WATER. DATA FROM JANUARY/FEBRUARY 1986, APRIL 1987, AND JANUARY 1988 ARE USED TO PLOT ISOCONCENTRATIONS, AS SHOWN IN FIGURES 12, 13, AND 14, RESPECTIVELY. THESE FIGURES INDICATE THAT ELEVATED CHROMIUM CONCENTRATIONS ARE PRESENT IN GROUND WATER PRIMARILY IN ON-SITE AREAS TO THE WEST OF THE SLURRY WALL. COMPARISON BETWEEN THE THREE SETS OF ISOCONCENTRATIONS INDICATES THE APPARENT TREND OF DECREASING CHROMIUM CONCENTRATIONS WITH TIME IN MONITORING WELLS LOCATED HYDRAULICALLY DOWNGRADIENT OF THE SLURRY CUTOFF WALL. IT SHOULD BE NOTED THAT THESE ISOCONCENTRATIONS HAVE BEEN DEVELOPED BASED ON DATA OBTAINED FROM ALL WELLS AND DO NOT DIFFERENTIATE BETWEEN THE VARIOUS STRATIGRAPHIC ZONES. HOWEVER, THE DATA REPRESENT PRIMARILY THE WATER QUALITY OF ZONE 1.

OF THE GROUND WATER MONITORING WELLS LOCATED HYDRAULICALLY DOWNGRADIENT OF THE SLURRY CUTOFF WALL, ONLY WELLS CWP-8 AND AT-2 HAVE OCCASIONALLY INDICATED THE PRESENCE OF CHROMIUM IN EXCESS OF THE DRINKING WATER STANDARD (0.05 MG/L). IN 1988, CHROMIUM CONCENTRATIONS IN WELL CWP-8 EXCEEDED THE DRINKING WATER STANDARD TWICE. OTHER OBSERVATIONS SHOWED CHROMIUM CONCENTRATIONS AT OR BELOW THE DETECTION LIMIT OF 0.01 MG/L. THE MOST RECENT DATA, FOR JUNE AND JULY 1989, SHOW LESS THAN 0.02 MG/L CHROMIUM CONCENTRATION IN WELL CWP-8. IN 1988, CHROMIUM CONCENTRATIONS IN

WELL CWP-8 RANGED FROM LESS THAN 0.02 TO 0.05 MG/L. EIGHT OBSERVATIONS SHOWED LESS THAN 0.02 MG/L CHROMIUM CONCENTRATIONS. EXCEPT IN JANUARY 1989, WHERE 0.04 MG/1 CHROMIUM WAS DETECTED, ALL OTHER DATA FOR 1989 SHOW LESS THAN 0.01 MG/1 CHROMIUM CONCENTRATION IN WELL AT-2. WELL AT-2 IS COMPLETED ENTIRELY WITHIN ZONE 1; HOWEVER, OTHER ZONE 1 MONITORING WELLS DOWNGRADIENT OF WELL AT-2 HAVE NOT SHOWN THE PRESENCE OF CHROMIUM. ALSO, ZONE 1 IN THE VICINITY OF WELL AT-2 DOES NOT CONTAIN DETECTABLE LEVELS OF CHROMIUM (GEOSYSTEM, JANUARY 1987).

TO DEMONSTRATE THE TREND OF DECREASING CHROMIUM CONCENTRATIONS WITH TIME, WATER QUALITY DATA OBTAINED FROM WELLS CWP-6, FPT-3, AND AT-I HAVE BEEN PLOTTED IN FIGURES 15, 16, AND 17, RESPECTIVELY. THE REDUCTION IN CONCENTRATION IS MORE EVIDENT IN OFF-SITE WELLS FPT-3 AND AT-I AS COMPARED WITH ON-SITE WELL CWP-6. THE DECLINE IN CHROMIUM CONCENTRATION WITH TIME IN WELL CWP-8, ON A SEMILOGARITHMIC BASIS, IS SHOWN IN FIGURE 18. THE AREA NEAR WELL CWP-8 IS ASSUMED TO BE THE POTENTIAL SOURCE OF CHROMIUM TO OFF-SITE AREAS, SINCE IT IS TO THE EAST OF THE SLURRY WALL AND NOT CONTAINED BY ON-SITE REMEDIATION EFFORTS. THE WATER QUALITY DATA FOR WELL CWP-6 (FIGURE 15) SHOW A CONSIDERABLE REDUCTION IN CHROMIUM CONCENTRATIONS FROM OVER 120 MG/L IN 1981 TO ABOUT 50 MG/L IN JUNE 1985. SINCE 1985, CHROMIUM CONCENTRATIONS HAVE VARIED SOMEWHAT; HOWEVER, THE OVERALL CONCENTRATIONS HAVE NOT CHANGED SIGNIFICANTLY. SIMILAR REDUCTIONS IN CHROMIUM CONCENTRATIONS CAN BE OBSERVED IN FIGURES 16 AND 17 FOR WELLS FPT-3 AND AT-2, RESPECTIVELY. THE CHROMIUM CONCENTRATIONS IN WELLS FPT-3 AND AT-I GENERALLY DEMONSTRATE A STEADY DECLINE IN CHROMIUM CONCENTRATIONS. THE CHROMIUM CONCENTRATION IN WELL FPT-3 HAS BEEN BELOW THE DRINKING WATER STANDARD OF 0.05 MG/L SINCE FEBRUARY 1986. ALSO, THE MOST RECENT WATER QUALITY DATA FOR WELL AT-2 (TABLE B-2 OF APPENDIX B) INDICATE THE CONCENTRATION OF CHROMIUM IS GENERALLY BELOW THE DETECTION LIMIT OF 0.02 MG/1. THE TRENDS IN CHROMIUM CONCENTRATIONS IN OFF-SITE AREAS ARE DISCUSSED FURTHER IN SECTION 6.0, WHICH ADDRESSES MIGRATION PATHWAYS AND RISK ASSESSMENT.

4.6 INDICATOR PARAMETERS

SITE CHARACTERIZATION STUDIES HAVE SHOWN THE PRESENCE OF CHROMIUM, COPPER, AND ARSENIC IN SOIL AND THE PRESENCE OF CHROMIUM IN GROUND WATER. THESE COMPOUNDS, THEREFORE, ARE CONSIDERED TO BE INDICATOR PARAMETERS FOR USE IN FURTHER SITE CHARACTERIZATION STUDIES AND POSSIBLE SOIL REMEDIATION ACTIVITIES. FOR MONITORING AND GROUND WATER REMEDIATION, HOWEVER, DISSOLVED TOTAL CHROMIUM AND CR(VI) ARE CONSIDERED TO BE THE MOST RELEVANT INDICATOR PARAMETERS. THE RATIONALE FOR THIS SELECTION IS THAT CHROMIUM COMPOUNDS, PARTICULARLY CR(VI), ARE MORE SOLUBLE AND MORE MOBILE IN THE SUBSURFACE ENVIRONMENT THAN ARSENIC AND COPPER COMPOUNDS. IN ADDITION, PREVIOUS MONITORING EFFORTS HAVE NOT DETECTED COPPER OR ARSENIC IN GROUND WATER.

4.7 GEOCHEMICAL PROPERTIES

TO EVALUATE THE MIGRATION RATE AND LEACHING CHARACTERISTICS OF CHROMIUM, A NUMBER OF GEOCHEMICAL TESTS WERE PERFORMED. THESE TESTS INCLUDED CHEMICAL ANALYSES FOR TOTAL CHROMIUM, CR (VI), ORGANIC MATTER, WASTE EXTRACTION TESTS (WET), BATCH SORPTION TESTS, AND COLUMN DESORPTION TESTS. DETAILED DESCRIPTIONS OF THESE TESTS AND TEST RESULTS HAVE BEEN SUBMITTED PREVIOUSLY (IT CORPORATION, JUNE 1985); HOWEVER, THE FINDINGS OF THESE STUDIES, PERTINENT TO THE RAP, ARE SUMMARIZED BELOW.

4.7.1 SOIL SAMPLE ANALYSES

NINE SOIL SAMPLES WERE SELECTED FOR ANALYSES TO DETERMINE THE RELATIVE CONCENTRATIONS OF TOTAL CHROMIUM AND CR(VI). THE RESULTS ARE PRESENTED IN TABLE D-5 OF APPENDIX D. THE DATA SHOW THAT THE CONCENTRATIONS OF CR(VI) IN THE SAMPLES ANALYZED ARE GENERALLY LESS THAN 10 PERCENT OF THE TOTAL CHROMIUM CONTENT. FROM THE DATA IT CAN BE CONCLUDED THAT MOST OF THE CHROMIUM PRESENT IN THE SOIL IS NOT IN HEXAVALENT FORM. PREVIOUS STUDIES HAVE SHOWN THAT THE TRIVALENT FORMS OF CHROMIUM UNDER NEUTRAL CONDITIONS ARE LESS SOLUBLE AND MORE SUBJECT TO ADSORPTION. CR(III) IS, THUS, LESS SUSCEPTIBLE TO DISSOLUTION AND IS LESS MOBILE.

THE ORGANIC CONTENT OF THE SOIL SAMPLES, REPORTED IN TABLE D-5 OF APPENDIX D, VARIED FROM LESS THAN 0.1 TO 0.86 PERCENT. ALTHOUGH THE ORGANIC CONTENT OF THE SOIL MAY NOT BE DIRECTLY RESPONSIBLE FOR ADSORPTION OF CR(VI), IT MAY REDUCE CR(VI) TO CR(III) (STOLLENWERK AND GROVE, 1985; JAMES AND BARTLETT, 1983). BECAUSE OF THE COMPLEXITY OF THE GEOCHEMICAL REACTIONS, THE OVERALL EFFECT OF ORGANIC MATTER ON THE REDUCTION OF CR(VI) TO CR(III) CANNOT BE ASSESSED.

4.7.2 WASTE EXTRACTION TESTS

TO EVALUATE THE LEACHING CHARACTERISTICS OF THE CONTAMINATED SOIL WITH RESPECT TO DISSOLVED TOTAL CHROMIUM, WASTE EXTRACTION TESTS (WETS) WERE PERFORMED ACCORDING TO THE GUIDELINES ISSUED BY THE DHS (JANUARY 1984). THE RATIONALE FOR PERFORMING THE TESTS FOR TOTAL CHROMIUM WAS THAT IT HAS BEEN SHOWN THAT A LARGE PERCENTAGE OF THE CHROMIUM IN THE SOIL IS IN TRIVALENT FORM. THE WET RESULTS ARE PRESENTED IN TABLE D.6 OF APPENDIX D. THE RESULTS SHOW THAT ACCORDING TO EXISTING CRITERIA THE SOIL IS NOT CONSIDERED A HAZARDOUS WASTE. ALTHOUGH THE WET RESULTS DO NOT PROVIDE ANY INFORMATION ON THE LONG-TERM LEACHABILITY OF CR (VI), THE TEST WAS DESIGNED TO EVALUATE THE LEACHING CHARACTERISTICS OF TOTAL CHROMIUM IN SOIL UNDER AGGRESSIVE ACIDIC CONDITIONS. THE LONG-TERM LEACHING BEHAVIOR OF CR(VI) COULD BE ASSESSED IF SUFFICIENT FIELD DATA WERE AVAILABLE. AT THIS TIME, HOWEVER, THE COLLECTION AND EVALUATION OF SUCH DATA, UNDER PARTIALLY SATURATED FLOW CONDITIONS AND IN HETEROGENEOUS SOILS, IS STILL IN THE RESEARCH STAGE.

4.7.3 SORPTION TESTS

TO EVALUATE THE MIGRATION CHARACTERISTICS OF CR(VI) IN GROUND WATER, BATCH SORPTION TESTS WERE PERFORMED ON UNCONTAMINATED SOIL SAMPLES. THE TESTS WERE PERFORMED ON TWO SAMPLES; ONE REPRESENTING THE SILTY CLAY MATERIAL OF ZONE 1 AND THE OTHER THE SAND AND GRAVEL OF ZONE 2. THE TESTS WERE PERFORMED FOR TWO INITIAL CONCENTRATIONS OF 1 AND 10 MG/L. THE RESULTS DEMONSTRATED THAT THE DISTRIBUTION COEFFICIENT (KD) VARIES FROM 0.65 TO 2.98 ML/G AND THE CORRESPONDING RETARDATION FACTORS (R) RANGE FROM 4.9 TO 12.4. THE RETARDATION FACTOR OF 4.9 REPRESENTS THE MINIMUM CALCULATED VALUE FOR THE SAND AND GRAVEL LAYER.

THE RESULTS OF BATCH SORPTION TESTS DEMONSTRATE THAT ADSORPTION ON THE SOIL MATRIX CAN OCCUR, RETARDING THE MIGRATION OF CR(VI). EVEN THOUGH ALL THE ADSORPTION MECHANISMS AND THEIR RELATIVE CONTRIBUTIONS ARE NOT KNOWN, THE RESULTS OF PREVIOUS STUDIES (STOLLENWERK AND GROVE, 1985) SUPPORT THE CONCLUSION THAT ADSORPTION OF CR(VI) ON ALLUVIAL MATERIALS IS LIKELY. THIS IS PARTICULARLY TRUE FOR SOILS CONTAINING HIGH CONCENTRATIONS OF IRON OXIDES. THE RESULTS OF THE SORPTION TESTS HAVE BEEN UTILIZED IN EVALUATING THE MIGRATION BEHAVIOR OF CHROMIUM (SECTION 6.0).

4.7.4 DESORPTION TESTS

DESORPTION TESTS HAVE BEEN PERFORMED TO EVALUATE THE BEHAVIOR OF CR(VI) IN THE PORE FLUID AS NONCONTAMINATED WATER FLOWS THROUGH CONTAMINATED SOIL. TWO SOIL SAMPLES, ONE CLASSIFIED AS SANDY GRAVEL AND THE OTHER AS CLAYEY SILT, WERE USED FOR THE DESORPTION STUDIES. SOLUTIONS OF SODIUM CHROMATE WERE FIRST USED TO CONTAMINATE THE SOIL SAMPLES. THE INITIAL CONCENTRATION OF THE INFLUENT TO THE SOIL COLUMNS WAS 10 MG/L. HOWEVER, SINCE ACHIEVING STEADY STATE CONDITIONS APPEARED TO BE VERY SLOW, THE INFLUENT CONCENTRATIONS WERE INCREASED TO 190 MG/L. THE RESULT OF THE CONTAMINATION PHASE OF THE DESORPTION TESTS SHOWED THAT MORE THAN 70 PORE VOLUMES WERE REQUIRED TO ACHIEVE STEADY STATE CONDITIONS. THIS MAY BE AN INDICATION THAT THE SOILS EXHIBIT A CONSIDERABLE ADSORPTIVE CAPACITY FOR CR(VI). LIMITED DATA ON THE IRON CONTENT OF THE SOILS UNDERLYING THE SITE INDICATED THE PRESENCE OF ABOUT 23,500 MG/KG OF IRON. OXIDES AND HYDROXIDES OF IRON MAY CONTRIBUTE TO THE ADSORPTION OF CR(VI) (STOLLENWERK AND GROVE, 1985; JAMES AND BARTLETT, 1983).

THE DESORPTION PHASE WAS CONDUCTED BY REPLACING THE INFLUENT SOLUTION WITH DISTILLED WATER. THE DATA SHOWED THAT ABOUT 10 PORE VOLUMES WERE REQUIRED TO REDUCE THE EFFLUENT CONCENTRATION OF CR(VI) FROM APPROXIMATELY 185 MG/L TO ABOUT 0.1 MG/L. THE RESULTS ALSO SHOWED THAT, IN THE LOW CONCENTRATION RANGE, THE RATE OF REDUCTION IN CONCENTRATION WAS VERY SLOW. HOWEVER, IT SHOULD BE NOTED THAT DESORPTION PER SE IS NOT A SLOW PROCESS.

IT SHOULD ALSO BE POINTED OUT THAT THE SORPTION AND DESORPTION STUDIES WERE CONDUCTED USING DISTILLED WATER AS A SOLVENT. THIS MAY AFFECT THE SORPTION/DESORPTION CHARACTERISTICS AS COMPARED TO THE ACTUAL FIELD CONDITIONS WHERE THE GROUND WATER CONTAINS A NUMBER OF OTHER CHEMICAL COMPOUNDS. FOR INSTANCE, THE ADSORPTION OF CR(VI) IN THE PRESENCE OF OTHER SALTS MAY BE REDUCED (STOLLENWERK AND GROVE, 1985) AND THE DESORPTION MAY BE ENHANCED. HOWEVER, THE LABORATORY DATA USING DISTILLED WATER ARE CONSIDERED TO HAVE GENERATED USEFUL INFORMATION UNDER HIGHLY CONTROLLED CONDITIONS. SINCE, THE GROUND WATER CHARACTERISTICS VARY WITH TIME UNDER ACTUAL FIELD CONDITIONS, IT APPEARS THAT THE LONG TERM GEOCHEMICAL BEHAVIOR CAN BEST BE EVALUATED BY STUDYING FIELD DATA. THE ADVANTAGE OF THIS APPROACH IS THAT ANY OBSERVATIONS REFLECT THE AGGREGATE EFFECT OF ALL HYDROGEOLOGIC AND GEOCHEMICAL PROCESSES OCCURRING IN THE FIELD.

THE GROUND WATER LEVEL FLUCTUATIONS AND WATER QUALITY DATA HAVE BEEN REVIEWED TO ASSESS POSSIBLE CORRELATION BETWEEN GROUND WATER LEVEL AND CHROMIUM CONCENTRATIONS. ALTHOUGH CERTAIN WELLS EXHIBITED A DISCERNABLE TREND OF INCREASING CHROMIUM CONCENTRATIONS WITH RISING GROUND WATER LEVELS, THE MAJORITY OF THE DATA DO NOT SUGGEST A RELATIONSHIP BETWEEN THE TWO FACTORS. THE COLUMN DESORPTION TEST DATA HAVE BEEN USED TO ESTIMATE THE DURATION OF AQUIFER CLEANUP IN TERMS OF PORE WATER VOLUMES EXTRACTED AS DISCUSSED IN SECTION 7.0.

#IRM

5.0 INTERIM REMEDIAL MEASURES

SINCE THE INITIATION OF INVESTIGATIONS AT THE CWP SITE, A NUMBER OF IMPROVEMENTS HAVE BEEN MADE TO THE FACILITIES AND SEVERAL INTERIM REMEDIAL MEASURES HAVE BEEN IMPLEMENTED. OVERALL IMPROVEMENTS TO THE CWP FACILITY INCLUDE EXTENSION OF THE AREA COVERED BY SURFACE PAVING, ERECTION OF CANOPIES OVER THE WOOD TREATMENT AREA, AND CONSTRUCTION OF BERMS TO DIVERT AND CONTROL SURFACE RUNOFF FROM TREATED WOOD STORAGE AREAS. SPECIFIC REMEDIAL MEASURES INCLUDE CONSTRUCTION OF A SLURRY CUTOFF WALL, INSTALLATION OF A GROUND WATER EXTRACTION TRENCH UPGRADIENT OF THE CUTOFF WALL, AND INSTALLATION OF A GROUND WATER EXTRACTION WELL NEAR THE RETORT AREA. EACH OF THESE MEASURES IS DESCRIBED IN THE FOLLOWING SECTIONS.

5.1 GENERAL FACILITY IMPROVEMENTS

IN RESPONSE TO RWQCB REQUESTS AND ON A VOLUNTARY BASIS, OVER THE PAST SEVERAL YEARS, CWP HAS IMPLEMENTED A NUMBER OF MEASURES TO REDUCE AND CONTROL SURFACE RUNOFF AND ELIMINATE THE SOURCE OF CHROMIUM TO SOIL AND GROUND WATER. THESE MEASURES HAVE INCLUDED GRADING AND CONSTRUCTION OF BERMS TO PREVENT SURFACE RUNOFF FROM THE RETORT AND TREATED WOOD STORAGE AREAS, SURFACE PAVING, AND THE CONSTRUCTION OF ROOFS OVER THE RETORT AREA. SURFACE GRADING AND BERM CONSTRUCTION WAS PERFORMED IN 1981 AND FOCUSED PRIMARILY ON THE RETORT AREA AND AREAS USED TO STORE TREATED WOOD. THE LOCATIONS OF THE BERMS ARE SHOWN IN FIGURE 2.

THE ASPHALT PAVING WAS EXTENDED TO THE NORTHERN AND SOUTHERN PORTIONS OF THE SITE IN 1979 AND 1981, RESPECTIVELY. THE AREAL EXTENT OF THE SURFACE PAVING IS SHOWN IN FIGURE 2. WITH THE EXCEPTION OF THE NARROW STRIP TO THE EAST OF THE SLURRY WALL, THE REMAINING UNPAVED AREAS, AS DEFINED IN FIGURE 2, WILL BE PAVED. THE PAVING SERVES TO REDUCE THE AMOUNT OF WATER SEEPING INTO THE SOIL AND POSSIBLY LEACHING CHROMIUM INTO GROUND WATER IN AREAS OF ELEVATED CHROMIUM CONCENTRATION. IN ADDITION, THE PAVING REDUCES THE LIKELIHOOD OF SPILLED WOOD PRESERVATIVES AND DRIPPINGS FROM TREATED WOOD DIRECTLY INFILTRATING THE SOIL. FORKLIFTS AND OTHER EQUIPMENT USED TO HANDLE TREATED WOOD ARE REQUIRED TO REMAIN IN CERTAIN AREAS TO AVOID TRACKING OF WOOD PRESERVING CHEMICALS TO AREAS WHERE SURFACE RUNOFF IS NOT CONTROLLED.

THREE LARGE ROOFS OR CANOPIES WERE ERECTED IN 1985 OVER THE RETORT AND ADJACENT AREA, AS SHOWN IN FIGURE 2. THESE COVERS PREVENT PRECIPITATION FROM FALLING DIRECTLY ONTO SURFACES WHERE WOOD PRESERVING CHEMICAL DRIPPINGS FROM TREATED WOOD MAY BE PRESENT. THE CLEAN RAIN WATER RUNNING OFF THESE ROOFS EVENTUALLY REPORTS TO SURFACE DRAINAGE DITCHES AROUND THE CWP FACILITY.

IT WAS OBSERVED THAT THE CONCRETE UTILITY BOX AROUND WELL CWP-10, LOCATED NEAR THE RETORT AREA, BECAME FILLED WITH WATER DURING HEAVY PRECIPITATION AT THE SITE. SAMPLES OF WATER FROM THE UTILITY BOX WERE COLLECTED AND ANALYZED. THE RESULTS INDICATED HIGH CHROMIUM CONCENTRATIONS. GROUND WATER SAMPLES FROM WELL CWP-10 HAD ALSO INDICATED A SUDDEN INCREASE IN CHROMIUM CONCENTRATIONS, FROM NONDETECTED TO RELATIVELY HIGH CONCENTRATIONS (APPENDIX B). IT WAS CONCLUDED THAT WELL CWP-10 WAS CONDUCTING CHROMIUM-CONTAINING SURFACE RUNOFF TO GROUND WATER. WELL CWP-10 WAS SUBSEQUENTLY ABANDONED BY GROUTING.

5.1.1 SLURRY WALL AND EXTRACTION TRENCH

IN OCTOBER 1983, CWP CONSTRUCTED A SLURRY CUTOFF WALL ALONG THE EASTERN SITE BOUNDARY. THE SLURRY WALL IS REPORTEDLY ABOUT 300 FEET LONG AND 20 FEET DEEP. CWP ALSO INSTALLED A GROUND WATER EXTRACTION TRENCH IMMEDIATELY TO THE WEST, HYDRAULICALLY UPGRADIENT OF THE SLURRY WALL. THE EXTRACTION TRENCH IS APPROXIMATELY 15 FEET-LONG, 18 FEET DEEP, AND 2 FEET WIDE. THE TRENCH IS GRAVEL-FILLED AND A 12-INCH DIAMETER EXTRACTION WELL, WELL HL-7, IS LOCATED APPROXIMATELY AT THE MID-POINT OF THE TRENCH. THE WELL CASING IS PERFORATED FROM 9 TO 19 FEET BELOW GRADE AND IS EQUIPPED WITH A PERMANENT, ELECTRIC SUBMERSIBLE PUMP. GROUND WATER EXTRACTED FROM THE TRENCH VIA WELL HL-7 IS USED DIRECTLY IN CWP'S WOOD PRESERVING OPERATIONS OR TRANSFERRED TO THE RECYCLED WATER TANK FOR SUBSEQUENT USE.

THE SLURRY WALL IS INTENDED TO INTERCEPT THE PLUME OF DISSOLVED CHROMIUM ORIGINATING NEAR THE RETORT AREA AND MIGRATING TO THE SOUTHWEST IN THE DIRECTION OF GROUND WATER FLOW. THE SLURRY WALL LOCATION AND CONFIGURATION WAS BASED ON THE KNOWN CHROMIUM PLUME AT THE TIME. THE EXTRACTION TRENCH AND WELL HL-7 ARE INTENDED TO REMOVE GROUND WATER IMPOUNDED BEHIND THE SLURRY WALL TO PREVENT FLOW AROUND THE NORTHERN AND SOUTHERN ENDS OF THE WALL. IT SHOULD BE NOTED THAT THE SLURRY WALL AND THE TRENCH WERE CONSTRUCTED BY CWP WITHOUT THE APPROVAL OF THE RWQCB AND WITHOUT PROFESSIONAL SUPERVISION.

5.2.1 RECYCLING/TREATMENT OF EXTRACTED GROUND WATER

IN THE DRIER SUMMER MONTHS, EXTRACTED GROUND WATER IS RECYCLED DIRECTLY INTO CWP'S WOOD PRESERVING OPERATIONS. IN THE WETTER WINTER MONTHS, WHEN A HIGHER RATE OF GROUND WATER EXTRACTION CAN BE ACHIEVED FROM WELL HL-7, THE EXTRACTED WATER THAT CANNOT BE UTILIZED IN CWP'S OPERATIONS COULD BE TREATED AND DISCHARGED, PROVIDED THE APPROPRIATE PERMITS ARE OBTAINED. GROUND WATER CAN BE TREATED USING THE EXISTING ELECTROCHEMICAL EQUIPMENT AT THE SITE. THE ELECTROCHEMICAL TREATMENT PROCESS PRODUCES EFFLUENT CONTAINING LESS THAN 0.05 MG/L OF DISSOLVED TOTAL CHROMIUM. THE OPERATION DETAILS OF THE ELECTROCHEMICAL UNIT ARE PROVIDED IN SECTION 7.2.4.

5.2.2 TREATED GROUND WATER DISPOSAL

AS MENTIONED ABOVE, EXCESS EXTRACTED GROUND WATER THAT CANNOT BE RECYCLED INTO WOOD PRESERVING OPERATIONS CAN BE TREATED BY ELECTROCHEMICAL PROCESS EQUIPMENT. CWP HAD PLANNED TO REINJECT THE TREATED GROUND WATER INTO THE WATER-BEARING ZONE VIA AN INJECTION WELL, WELL CWP-19, LOCATED TO THE WEST (HYDRAULICALLY UPGRADIENT) OF THE RETORT AREA.

WELL CWP-19 WAS INSTALLED IN AUGUST 1985 IN AN OPEN TRENCH (IT CORPORATION, SEPTEMBER 1985). THE TRENCH WAS EXCAVATED USING A BACKHOE AND IS 25 FEET LONG, 2.5 FEET WIDE, AND 14 FEET DEEP. AN 8-INCH DIAMETER, FLUSH-THREADED WELL CASING WAS THEN INSTALLED APPROXIMATELY IN THE CENTER OF THE TRENCH. THE WELL CASING IS PERFORATED FROM 6 TO 24 FEET BELOW GRADE. THE TRENCH WAS THEN BACKFILLED WITH WASHED PEA GRAVEL AND A SURFACE SEAL OF 5 FEET OF IMPORTED, MEDIUM-TEXTURED SOIL WAS PLACED AND COMPACTED.

ACCORDING TO CWP, INJECTION WELL CWP-19 HAS NOT BEEN EFFECTIVE IN ACCEPTING LARGE VOLUMES OF TREATED WATER, PARTICULARLY DURING THE WET, WINTER MONTHS WHEN GROUND WATER LEVELS ARE HIGH. THIS IS OF CONCERN AS THE VOLUME OF GROUND WATER EXTRACTED FROM WELLS CWP-18 AND HL-7 IS HIGHEST DURING THE WINTER MONTHS AND, CONSEQUENTLY, THE VOLUME OF WATER TO BE DISPOSED IS ALSO HIGHEST. AFTER EVALUATING THIS METHOD OF DISPOSAL OF TREATED GROUND WATER, INJECTION WAS JUDGED TO BE INAPPROPRIATE DURING THE WINTER MONTHS AND HIGH GROUND WATER LEVEL CONDITIONS. UNDER SUCH CONDITIONS, DISCHARGE IN THE UKIAH SANITARY SEWER SYSTEM SEEMS APPROPRIATE. DURING SUMMER MONTHS, HOWEVER, INJECTION INTO WELL CWP-19 MAY BE A FEASIBLE ALTERNATIVE, IF RECYCLING IS NOT POSSIBLE OR NEEDED.

5.2.3 OBSERVATION WELLS CWP-20 AND CWP-21

ON AUGUST 30, 1985, OBSERVATION WELLS CWP-20 AND CWP-21 WERE INSTALLED AT THE NORTHERN AND SOUTHERN ENDS, RESPECTIVELY, OF THE SLURRY CUTOFF WALL. THE LOCATIONS OF THESE WELLS ARE SHOWN IN FIGURE 2. THE PURPOSE OF THESE WELLS WAS TO ENABLE AN ASSESSMENT OF THE EFFECTIVENESS OF EXTRACTION FROM WELL HL-7 AND THE INTEGRITY OF THE SLURRY WALL.

WELLS CWP-20 AND CWP-21 WERE INSTALLED IN 8-INCH DIAMETER BORINGS DRILLED TO 23 AND 22 FEET, RESPECTIVELY. BOTH WELLS WERE COMPLETED WITH 2-INCH DIAMETER, FLUSH-THREADED PVC WELL CASINGS WITH 0.020-INCH, MACHINE-CUT SLOTS. WELL CWP-20 IS PERFORATED FROM 5 TO 23 FEET BELOW GRADE AND WELL CWP-21 FROM 5 TO 20 FEET. SAND PACKS OF NO. 3 GRADE SILICA SAND WERE INSTALLED TO ABOUT THE TOP OF THE PERFORATED INTERVAL. THE SCREENED ZONES WERE THEN SEALED WITH APPROXIMATELY 1 TO 1.3 FEET OF BENTONITE PELLETS AND GROUTED WITH CONCRETE UP TO THE GROUND SURFACE.

THE STRATIGRAPHY ENCOUNTERED DURING DRILLING INDICATES THAT NEITHER WELL INTERCEPTS THE MORE PERMEABLE ZONE 2, ALTHOUGH WELL CWP-21 APPARENTLY INTERCEPTS A SUBSTANTIAL GRAVEL LAYER BETWEEN 7.5 AND 14 FEET DEPTH. WELLS CWP-20 AND CWP-21 WERE USED AS OBSERVATION WELLS DURING EVALUATIONS OF THE EFFECTIVENESS OF THE SLURRY WALL AND EXTRACTION TRENCH.

5.2.4 PERFORMANCE EVALUATION

THE PERFORMANCE OF THE SLURRY WALL AND EXTRACTION TRENCH IN CONTAINING THE CHROMIUM PLUME AND REMEDIATING THE GROUND WATER HAS BEEN ASSESSED BY EVALUATING GROUND WATER QUALITY DATA AND BY A SERIES OF PUMPING TESTS.

GROUND WATER QUALITY DATA OBTAINED SINCE 1981 (TABLE B.2, APPENDIX B) DEMONSTRATE THAT THE INSTALLATION OF THE SLURRY CUTOFF WALL AND EXTRACTION OF GROUND WATER FROM WELL HL-7 HAVE RESULTED IN A REDUCTION IN CHROMIUM CONCENTRATIONS IN WELLS LOCATED HYDRAULICALLY DOWNGRADIENT OF THE SLURRY WALL. THE IMPROVEMENT IN GROUND WATER QUALITY SUBSEQUENT TO 1983 HAS BEEN DISCUSSED IN SECTION 4.5.3 THEREFORE, THESE INTERIM REMEDIAL MEASURES ARE BELIEVED TO HAVE BEEN EFFECTIVE IN REDUCING OFF-SITE MIGRATION.

TWO PUMPING TESTS WERE PERFORMED TO EVALUATE THE EFFECTIVENESS OF EXTRACTION FROM WELL HL-7 IN CONTAINING THE CHROMIUM PLUME AND TO ASSESS THE INTEGRITY OF THE SLURRY CUTOFF WALL. ONE TEST WAS PERFORMED IN FEBRUARY 1986, AND THE OTHER IN JULY 1986 WHEN WATER LEVELS WERE LOW. THE RESULTS OF THESE TESTS DEMONSTRATED THAT EXTRACTION FROM WELL HL-7 IS EFFECTIVE IN CONTAINING THE PLUME NEAR THE SOUTHERN END OF THE SLURRY WALL WHERE WELL CWP-21 IS LOCATED. THE RESULTS WERE NOT CONCLUSIVE IN DEMONSTRATING THAT HYDRAULIC CONTAINMENT OF THE PLUME IS ACHIEVED NEAR THE NORTHERN END OF THE SLURRY WALL. HOWEVER, WATER QUALITY DATA INDICATE THAT THERE IS NO PLUME MIGRATION IN THE ZONE INTERCEPTED BY WELL CWP-20 LOCATED AT THE NORTHERN END OF THE SLURRY CUTOFF WALL.

THE DETAILS OF THE PUMPING TESTS HAVE BEEN PRESENTED IN TECHNICAL REPORTS (GEOSYSTEM, MARCH 1986; GEOSYSTEM, SEPTEMBER 1986), COPIES OF WHICH HAVE BEEN SUBMITTED TO THE APPROPRIATE REGULATORY AGENCIES.

5.3 RETORT AREA RECOVERY WELL

ON AUGUST 29, 1985, A LARGE DIAMETER RECOVERY WELL, CWP-18, WAS INSTALLED IN THE RETORT AREA AT THE LOCATION SHOWN IN FIGURE 2. ALTHOUGH THE INSTALLATION OF THIS WELL HAS BEEN PREVIOUSLY REPORTED (IT CORPORATION, SEPTEMBER 25, 1985), A BRIEF DISCUSSION IS INCLUDED FOR COMPLETENESS.

WELL CWP-18 WAS INSTALLED IN A 36-INCH DIAMETER BORING, ADVANCED TO A TOTAL DEPTH OF 14 FEET AND INTERCEPTING ONLY ZONE 1. AN 8-INCH DIAMETER, FLUSH-THREADED WELL CASING WAS INSTALLED. THE CASING IS PERFORATED FROM 5 TO 14 FEET BELOW GRADE WITH 0.020-INCH, MACHINE CUT SLOTS. SAND PACK OF NO. 3 GRADE SILICA SAND WAS INSTALLED UP 6 FEET BELOW GRADE AND SEALED WITH 200 LBS OF 0.25-INCH BENTONITE PELLETS EMPLACED. THE REMAINING ANNULAR SPACE WAS CONCRETED TO THE GROUND SURFACE.

ON FEBRUARY 13, 1986, A SHORT DURATION PUMPING TEST WAS CONDUCTED (GEOSYSTEM, MARCH 1986). GROUND WATER LEVELS AT THE CWP SITE WERE AT OR VERY NEAR THE SEASONAL HIGH AT THIS TIME OF YEAR. WATER LEVELS WERE MEASURED IN THE PUMPING WELL AND IN NEARBY MONITORING WELL CWP-6. THE OBJECTIVE OF THIS PUMPING TEST WAS TO EVALUATE THE MAXIMUM YIELD OF WELL CWP-18 AND TO ESTIMATE THE HYDROGEOLOGIC CHARACTERISTICS OF ZONE 1 IN THE RETORT AREA.

THE PUMPING TEST DEMONSTRATED THAT WELL CWP-18 CAN BE EFFECTIVE IN REMOVING HIGHLY CONTAMINATED GROUND WATER FROM ZONE 1 IN THE RETORT AREA. EXTRACTION, HOWEVER, MUST BE AT A LOW, CONTINUOUS RATE, ON THE ORDER OF 0.5 TO 2.0 GPM, OR BY INTERMITTENT PUMPING AT A HIGHER DISCHARGE RATE. DURING THE DRY SEASON, WHEN GROUND WATER LEVELS IN ZONE 1 DROP SIGNIFICANTLY, WELL CWP-18 IS EXPECTED TO BE LESS EFFECTIVE.

CWP-18 IS NOT EXPECTED TO CONTAIN THE PLUME IN THE DOWNGRADIENT DIRECTION. HOWEVER, THIS PORTION OF THE PLUME SHOULD BE CAPTURED/CONTAINED BY EXTRACTION FROM WELL HL-7 AND THE SLURRY WALL.

#RA
RISK ASSESSMENT

THE PURPOSE OF THIS ASSESSMENT IS TO IDENTIFY AND ASSESS THE POTENTIAL MIGRATION PATHWAYS AND EXPOSURE MECHANISMS BY WHICH CONTAMINANTS IN SOIL AND GROUND WATER IN THE STUDY AREA MAY CAUSE POSSIBLE HEALTH RISKS AND ADVERSE ENVIRONMENTAL IMPACTS. THE INFORMATION PRESENTED IN THIS SECTION CORRESPONDS TO THE REQUIREMENTS OF SECTIONS 5 AND 6 OF THE RAP GUIDELINES.

SYSTEMATIC RISK ASSESSMENT INCLUDES SITE CHARACTERIZATION, HAZARD IDENTIFICATION, AND FATE

ANALYSIS. THE SITE HAS BEEN CHARACTERIZED BY A NUMBER OF INVESTIGATIONS, THE RESULTS OF WHICH ARE SUMMARIZED IN SECTION 4.0. HAZARD IDENTIFICATION IS PERFORMED BY ESTABLISHING THE PRIMARY CONTAMINANTS OR INDICATOR PARAMETERS AND, BASED ON AVAILABLE DATA, EVALUATING THE LEVEL OF HAZARD TO HUMAN HEALTH AND THE ENVIRONMENT. CHROMIUM AND ARSENIC HAVE BEEN SELECTED AS THE INDICATOR PARAMETERS BASED ON THEIR OCCURRENCE IN SOIL AND GROUND WATER, THEIR GEOCHEMICAL BEHAVIOR, AND THEIR TOXICITY. ACCORDINGLY, THE RISK ASSESSMENT PRESENTED HEREIN HAS BEEN PERFORMED FOR THESE COMPOUNDS. FATE ANALYSIS CONSIDERS MIGRATION PATHWAYS IN ORDER TO IDENTIFY THE POTENTIAL EXPOSURE OF CONTAMINANTS TO RECEPTORS.

BASED ON THE ABOVE, THE RISK ASSESSMENT INCLUDES AN EVALUATION OF POTENTIAL MIGRATION PATHWAYS, DOCUMENTATION OF TOXICITY, A DESCRIPTION OF THE POPULATION POTENTIALLY AT RISK, AN EXPOSURE ASSESSMENT, AND A DESCRIPTION OF RISK CHARACTERISTICS. THE EMPHASIS IN THIS ASSESSMENT HAS BEEN PLACED ON HEALTH RATHER THAN ECOLOGICAL IMPACTS. ALSO, BECAUSE OF CURRENT ZONING AND THE EXPECTED INDUSTRIAL USE SUBSEQUENT TO SITE CLOSURE, THE RESULTS OF THE RISK ASSESSMENT ARE BELIEVED TO BE APPLICABLE TO POST-CLOSURE CONDITIONS.

MIGRATION PATHWAYS

POTENTIAL MIGRATION PATHWAYS INCLUDE AIRBORNE PARTICULATE MATTER AND DIRECT EXPOSURE TO SOIL, SURFACE WATER, AND GROUND WATER. EACH OF THESE PATHWAYS IS ADDRESSED BELOW.

6.1.1 MIGRATION THROUGH AIR

POTENTIAL SOURCES OF CHROMIUM, ARSENIC, AND COPPER IN THE AIR INCLUDE CONTAMINATED SOIL AND CWP'S WOOD PRESERVING OPERATIONS. MONITORING OF AIR EMISSIONS FROM CWP'S WOOD PRESERVING PROCESS HAS BEEN PERFORMED PERIODICALLY; HOWEVER EVALUATION OF THE RESULTING AIR QUALITY DATA IS NOT WITHIN THE SCOPE OF THIS RAP.

CONTAMINATED SOIL EXPOSED TO THE ATMOSPHERE MAY DRY AND SOIL PARTICLES CAN ENTER THE ATMOSPHERE AS DUST. THUS, CHROMIUM, ARSENIC, AND COPPER COULD BE CARRIED BY SOIL PARTICLES AND DISPERSED INTO THE ATMOSPHERE ACCORDING TO THE PREVAILING CLIMATIC CONDITIONS. AS POINTED OUT IN SECTION 5.1, HOWEVER, ESSENTIALLY ALL AREAS WHERE NEAR-SURFACE SOILS ARE KNOWN TO CONTAIN ELEVATED CONCENTRATIONS OF CHROMIUM, ARSENIC, AND COPPER HAVE BEEN PAVED. THEREFORE, THERE IS NOT BELIEVED TO BE A SIGNIFICANT POTENTIAL FOR CHROMIUM, ARSENIC, AND COPPER FROM ON-SITE SURFACE SOILS TO MIGRATE THROUGH AIR. SOILS WITH BACKGROUND CONCENTRATIONS OF CHROMIUM, ARSENIC, AND COPPER IN THE STUDY AREA COULD INTRODUCE THESE CONSTITUENTS INTO THE ATMOSPHERE, BUT AT INSIGNIFICANT LEVELS.

NO SITE-SPECIFIC BACKGROUND AIR QUALITY MONITORING DATA ARE AVAILABLE; HOWEVER, THE CONCENTRATIONS OF TOTAL CHROMIUM MEASURED IN AMBIENT AIR IN MANY URBAN AND NON-URBAN AREAS OF THE UNITED STATES, FROM 1977 TO 1980, HAVE BEEN DOCUMENTED (US EPA, AUGUST 1984). THE CONCENTRATIONS RANGE FROM LESS THAN 0.0060 MG/M3 TO GREATER THAN 0.6000 MG/M3. THE MEAN CHROMIUM CONCENTRATIONS IN NON-URBAN, BACKGROUND AREAS SUCH AS NATIONAL PARKS RANGED FROM 0.0052 MG/M3 TO 0.0090 MG/M3 OVER THE 1977 TO 1980 PERIOD. SELECTED DATA CONSIDERED TO BE REPRESENTATIVE OF THE RANGE OF TOTAL CHROMIUM CONCENTRATIONS IN AIR, HAVE BEEN SUMMARIZED IN TABLE 8.

IN SUMMARY, UNDER NORMAL CONDITIONS, THERE IS NOT BELIEVED TO BE A SIGNIFICANT CONTRIBUTION OF CHROMIUM, ARSENIC, AND COPPER TO THE ATMOSPHERE THROUGH THE RESIDUAL CONTAMINATED SOIL AT THE SITE. EXCAVATION AND REMOVAL OR OTHER SOIL DISTURBANCE MAY, HOWEVER, PROVIDE A POTENTIAL AIR PATHWAY. THIS PATHWAY WOULD REQUIRE A DETAILED EVALUATION IF EXCAVATION/REMOVAL WERE TO BE SELECTED AS A REMEDIAL ALTERNATIVE OR IF SOME OTHER SOIL DISTURBANCE OCCURRED. THE EVALUATION WOULD INCLUDE AIR MONITORING AND COMPARISON OF THE RESULTING DATA WITH BACKGROUND CONCENTRATIONS FOR HAZARD DETERMINATION.

6.1.2 DIRECT EXPOSURE

THE MOST DIRECT PATHWAY FOR CHROMIUM, COPPER, AND ARSENIC TO IMPACT HUMAN HEALTH AND THE ENVIRONMENT IS THROUGH CONTACT WITH CONTAMINATED SOIL. AS DESCRIBED IN SECTION 5.1, TEE AREAS WHERE NEAR-SURFACE SOILS ARE KNOWN TO HAVE BEEN IMPACTED ARE PAVED WITH ASPHALT OR CONCRETE. DIRECT EXPOSURE WOULD BE LIKELY ONLY IF THESE SOILS WERE EXCAVATED OR DISTURBED. THUS, SUCH EXPOSURES WOULD MOST LIKELY OCCUR DURING THE CLOSURE OF THE PLANT AND THE SUBSEQUENT REMEDIATION OF THE SITE.

ACCORDING TO TESTS PERFORMED ON SOIL SAMPLES COLLECTED IN THE STUDY AREA, THE BACKGROUND CONCENTRATIONS OF CHROMIUM, ARSENIC, AND COPPER ARE LESS THAN 50, 14, AND 20 MG/KG, RESPECTIVELY (TABLE D-1, APPENDIX D). FOR COMPARISON, CHROMIUM CONCENTRATIONS IN SOILS AT SELECTED LOCATIONS IN THE UNITED STATES ARE SUMMARIZED IN TABLE 9. THE CONCENTRATION OF CHROMIUM IN SOIL VARIES ACCORDING TO ITS ORIGIN. COMPARING THE CHROMIUM CONCENTRATIONS OF SURFACE SOILS AT THE CWP SITE WITH CONCENTRATIONS PRESENTED IN TABLE 9, SITE BACKGROUND CONCENTRATIONS ARE NEAR THE UPPER BOUNDARY OF THE RANGE OF MEDIAN CONCENTRATIONS MEASURED AT THE SELECTED LOCATIONS.

6.1.3 MIGRATION THROUGH SURFACE WATER

POTENTIAL SURFACE WATER MIGRATION PATHWAYS INCLUDE SHEET FLOW OVER THE SITE AND CHANNEL FLOW IN THE SURFACE DRAINS. RUNOFF FROM THE SITE IS COLLECTED IN UNLINED DITCHES AROUND THE PERIMETER OF THE SITE. THE DITCHES EVENTUALLY DISCHARGE INTO THE RUSSIAN RIVER, ALSO THROUGH UNLINED DITCHES. SURFACE RUNOFF FROM THE TREATED WOOD STORAGE AND RETORT AREAS IS COLLECTED IN A SUMP AND RECYCLED INTO CWP'S WOOD PRESERVING OPERATIONS.

ACCORDING TO RWQCB STAFF, FLOW IN THE SURFACE DRAINS MAY BE CONTINUOUS DURING THE WINTER MONTHS DUE TO THE INFLOW OF GROUND WATER. ALSO, DURING PERIODS OF HIGH PRECIPITATION, THE WATER LEVELS IN THE DITCHES RISE TO NEAR THE SURROUNDING LAND SURFACE. OBSERVATIONS MADE BY CWP PERSONNEL INDICATE THAT INTENSE PRECIPITATION RESULTS IN FLOW IN ALL SURFACE DRAINS SURROUNDING THE SITE. DURING LIGHT RAINFALL, HOWEVER, STORM WATER RAPIDLY INFILTRATES INTO THE VALLEY FILL THROUGH THE UNLINED DITCHES AND NO FLOW IS RECORDED AT STATION C-100 (FIGURE 2).

IN ACCORDANCE WITH RWQCB REQUIREMENTS, CWP PERSONNEL PERIODICALLY MONITOR STORM WATER QUALITY DURING PRECIPITATION EVENTS OF SUFFICIENT INTENSITY AND DURATION TO CAUSE FLOW IN THE DITCHES AROUND THE SITE. THE RESULTS OF STORM WATER QUALITY MONITORING ARE PRESENTED IN APPENDIX C. THE HIGHEST RECORDED CONCENTRATIONS WERE 0.630 MG/L AND 0.790 MG/L FOR CR(VI) AND TOTAL CHROMIUM, RESPECTIVELY, ON MARCH 13, 1984. RECENT STORM WATER QUALITY DATA HAVE INDICATED CHROMIUM CONCENTRATIONS TO BE AT OR BELOW THE DRINKING WATER STANDARD OF 0.05 MG/L ON ALL BUT A FEW OCCASIONS. RECENT STORM WATER MONITORING DATA FOR MONITORING STATIONS NE, NW, AND C-100 SHOW THAT CONCENTRATIONS OF CHROMIUM AND ARSENIC WERE LESS THAN 0.02 AND 0.004 MG/L, RESPECTIVELY WHICH DETECTION LIMITS FOR THE COMPOUNDS TESTED (GEOSYSTEM, APRIL 1989) A SUMMARY OF WATER QUALITY CRITERIA IS PRESENTED IN TABLE 10.

6.1.4 MIGRATION THROUGH GROUND WATER

THE MOST PROBABLE PATHWAY FOR CHEMICAL MIGRATION FROM THE CWP SITE IS VIA GROUND WATER. THE DATA REPRESENTING THE JANUARY 1988 (FIGURE 14) CONDITIONS INDICATE THAT ELEVATED CHROMIUM CONCENTRATIONS ARE DETECTED PRIMARILY ON SITE, TO THE WEST AND HYDRAULICALLY UPGRADIENT OF THE SLURRY CUTOFF WALL. THE ISOCONCENTRATION LINES REPRESENT THE AREAL EXTENT OF CHROMIUM CONTAMINATION IN THE UPPERMOST WATER-BEARING ZONE, ZONE 1. BECAUSE OF THE SOUTHEASTERLY FLOW DIRECTION, THE DISSOLVED CHROMIUM COMPOUNDS HAVE A TENDENCY TO MIGRATE IN THE SAME DIRECTION, TOWARD THE SLURRY WALL. THE CONCENTRATIONS, HOWEVER, DECREASE WITH DISTANCE FROM THE RETORT AREA.

THE RATE OF MIGRATION OF CHROMIUM IN ON-SITE AREAS DEPENDS PRIMARILY ON THE SEEPAGE VELOCITY OF GROUND WATER AND SORPTION CHARACTERISTICS OF CHROMIUM. PREVIOUS ANALYSES (IT CORPORATION, JUNE 1985) HAVE INDICATED THAT THE MIGRATION RATE OF THE CHROMIUM FRONT AT THE SITE IS ABOUT 58 FEET PER YEAR. IN THIS ESTIMATION, THE LOWEST RETARDATION FACTOR, REPRESENTING THE LOWEST DISTRIBUTION COEFFICIENT, WAS USED TO PROVIDE A CONSERVATIVE ANALYSIS. A CONSERVATIVE ANALYSIS IN THIS CASE IS ONE RESULTING IN LARGER MIGRATION RATES AND HIGHER DOWNGRADIENT CONCENTRATIONS. THE ANALYSIS IS ALSO CONSERVATIVE BECAUSE GROUND WATER FLOW AND CHROMIUM TRANSPORT WERE ASSUMED TO BE ONE-DIMENSIONAL. ALTHOUGH THE FLOW MAY BE UNIFORM AND REPRESENTED ONE-DIMENSIONALLY, CHROMIUM TRANSPORT IS TWO-DIMENSIONAL.

HYDRAULIC AND GROUND WATER QUALITY DATA, OBTAINED FROM PUMPING TESTS AND REGULAR GROUND WATER MONITORING, INDICATE THAT THE CHROMIUM FRONT IS INTERCEPTED BY THE SLURRY WALL. WATER IMPOUNDED BEHIND THE SLURRY WALL IS THEN EXTRACTED VIA WELL HL-7. IT IS NOTED THAT WITHOUT SOME FORM OF HYDRAULIC CONTROL, IN THIS CASE GROUND WATER EXTRACTION, IMPOUNDED WATER WOULD EVENTUALLY FLOW AROUND AND BENEATH THE SLURRY WALL AND CHROMIUM WOULD CONTINUE TO MIGRATE IN THE DOWNGRADIENT DIRECTION. CONSTRUCTION OF THE SLURRY WALL AND EXTRACTION FROM WELL HL-7 HAVE SUBSTANTIALLY REDUCED DISSOLVED CHROMIUM CONCENTRATIONS IN OFF-SITE AREAS.

THE PRESENCE OF CHROMIUM IN OFF-SITE AREAS IS BELIEVED TO HAVE RESULTED PRIMARILY FROM MIGRATION PRIOR TO CONSTRUCTION OF THE SLURRY WALL IN OCTOBER 1983. SINCE THEN, THE CONCENTRATIONS OF CHROMIUM IN OFF-SITE WELLS HAVE GRADUALLY DECREASED, AS DISCUSSED IN SECTION 4.5.3. GROUND WATER QUALITY DATA FROM OFF-SITE WELLS, OBTAINED IN JANUARY 1988, SHOW THAT CHROMIUM CONCENTRATIONS WERE BELOW THE DRINKING WATER STANDARD OF 0.05 MG/L. ALTHOUGH CHROMIUM CONCENTRATIONS IN WELL AT-2, LOCATED IN THE PEAR ORCHARD, HAVE OCCASIONALLY EXCEEDED THE DRINKING WATER STANDARD, THE DATA REPRESENTING 1989 CONDITIONS SHOW LESS THAN 0.05 MG/L AND GENERALLY LESS THAN THE DETECTION LIMIT OF 0.02 MG/L.

THE GROUND WATER QUALITY DATA INDICATE THAT BECAUSE OF THE OVERALL SITE IMPROVEMENTS AND THE INTERIM REMEDIAL MEASURES IMPLEMENTED, OFF-SITE MIGRATION IS LIMITED. TO ADDRESS POTENTIAL OFF-SITE MIGRATION FOR RISK ASSESSMENT PURPOSES, HOWEVER, A TWO-DIMENSIONAL AREAL MODEL HAS BEEN USED. DETAILS OF THIS MODELING EFFORT ARE PRESENTED IN APPENDIX E. THE MODEL HAS BEEN USED TO PREDICT THE DOWNGRADIENT DISTRIBUTION OF CHROMIUM UNDER UNIFORM FLOW CONDITIONS CONSIDERING VARIOUS MANAGEMENT PRACTICES. THE MODEL RESULTS HAVE SHOWN THE FOLLOWING:

- OF THE PREDICTED CHROMIUM CONCENTRATIONS ARE LESS THAN 0.05 MG/L AT A DISTANCE OF ABOUT 250 METERS (820 FEET) TO THE SOUTHEAST OF THE SLURRY WALL. THIS DISTANCE CORRESPONDS APPROXIMATELY TO THE LOCATION OF WELL AT-5. CHROMIUM HAS NOT BEEN DETECTED IN THIS WELL SINCE ITS INSTALLATION IN DECEMBER 1986.

- THE PREDICTED CHROMIUM CONCENTRATIONS AT OTHER RECEPTORS BEYOND WELL AT-5 ARE BELOW THE DETECTION LIMIT OF 0.02 MG/L.

- AN INCREASE IN THE CHROMIUM CONCENTRATION IN THE ASSUMED SOURCE AREA (NEAR WELL CWP-8), TO ABOUT 1 MG/L FOR SHORT DURATIONS, WILL NOT RESULT IN CHROMIUM CONCENTRATIONS HIGHER THAN 0.05 MG/L AT THE NEAREST RECEPTOR.

THE MODEL RESULTS INDICATE THAT FLUCTUATIONS IN CHROMIUM CONCENTRATIONS IN THE ASSUMED SOURCE AREA (PRIMARILY WELL CWP-8), WITHIN THE RANGE OBSERVED SINCE SLURRY WALL CONSTRUCTION, WILL NOT RESULT IN CHROMIUM CONCENTRATIONS HIGHER THAN DRINKING WATER STANDARDS IN THE NEARBY RECEPTORS. OFF-SITE CONTAMINATION IS LIKELY ONLY IF HIGH CHROMIUM CONCENTRATIONS ARE ALLOWED TO MIGRATE BEYOND THE SLURRY WALL AND PERSIST FOR A LONG DURATION. HOWEVER, MODEL SIMULATIONS (APPENDIX E) HAVE SHOWN THAT IF THE CONCENTRATIONS OF CHROMIUM AT WELL CWP-8 REMAIN AT ABOUT 1 MG/L FOR FOUR YEARS, DOWNGRADIENT CONCENTRATION AT ABOUT 820 FEET FROM WELL CWP-8 MAY APPROACH 0.05 MG/L.

6.2 OCCURRENCE, INTAKE, AND TOXICITY CHARACTERISTICS OF CHROMIUM AND ARSENIC

CHROMIUM, COPPER, AND ARSENIC ARE ELEMENTS WHICH ARE FOUND NATURALLY IN FOOD, WATER, AND AIR. EXPOSURE OF HUMAN BEINGS TO THESE ELEMENTS AT LEVELS WHICH EXCEED NATURAL CONCENTRATIONS MAY LEAD TO ADVERSE HEALTH EFFECTS. BASED ON THE OCCURRENCE OF METALS AT THE SITE, THEIR CONCENTRATIONS AND RELATIVE TOXICITY, THE SUBJECT EVALUATION PERTAINS ONLY TO CHROMIUM AND ARSENIC. DETAILS RELATED TO THE OCCURRENCE, INTAKE MECHANISMS, AND TOXICITY CHARACTERISTICS OF CHROMIUM AND ARSENIC ARE PRESENTED IN APPENDIX F.

6.3 PUBLIC HEALTH AND POPULATION DENSITY

THIS SECTION SUMMARIZES THE INFORMATION RELATED TO PUBLIC HEALTH PROTECTION GOALS AND POPULATION POTENTIALLY AT RISK.

6.3.1 PUBLIC HEALTH PROTECTION STANDARDS

PUBLIC HEALTH PROTECTION GOALS ARE ESTABLISHED BY PUBLIC HEALTH AND REGULATORY AGENCIES. RECOMMENDED OR ESTABLISHED STANDARDS FOR CHROMIUM IN THE UNITED STATES ARE SUMMARIZED IN TABLE 11. FOR PROTECTION OF HUMAN HEALTH FROM THE TOXIC PROPERTIES OF CR(III) INGESTED THROUGH WATER AND CONTAMINATED AQUATIC ORGANISMS, THE AMBIENT WATER CRITERION HAS BEEN DETERMINED TO BE 170 UG/L. FOR PROTECTION OF HUMAN HEALTH FROM THE TOXIC PROPERTIES OF CR(III) INGESTED THROUGH CONTAMINATED AQUATIC ORGANISMS ALONE, THE AMBIENT WATER CRITERION HAS BEEN DETERMINED TO BE 3,433 UG/L. THE AMBIENT WATER QUALITY CRITERION FOR TOTAL CR(VI) IS RECOMMENDED TO BE IDENTICAL TO THE EXISTING DRINKING WATER STANDARD, WHICH IS 0.05 MG/L.

6.3.2 POPULATION POTENTIALLY AT RISK

USING POPULATION DENSITY STATISTICS (GREATER UKIAH CHAMBER OF COMMERCE, JUNE 1987) AND THE RESULTS OF A SURVEY AND INTERVIEWS BY GEOSYSTEM PERSONNEL, THE ESTIMATED NUMBER OF PEOPLE LIVING IN THE STUDY AREA WITHIN ONE-HALF MILE FROM THE SITE VARIES SEASONALLY FROM ABOUT 20 TO 100. THIS POPULATION IS POTENTIALLY AT RISK IN RELATION TO SURFACE WATER AND GROUND WATER MIGRATION PATHWAYS. THE POPULATION DISTRIBUTION AROUND THE SITE IS ADDRESSED IN MORE DETAIL IN SECTION 3.2.4.

6.4 EXPOSE ASSESSMENT AND RISK CHARACTERIZATION

BASED ON THE EVALUATION OF POTENTIAL MIGRATION PATHWAYS AND THE POPULATION POTENTIALLY AT RISK, AN EXPOSURE ASSESSMENT HAS BEEN PERFORMED AND THE RISK ASSOCIATED WITH THE EXPOSURE CHARACTERIZED.

6.4.1 POTENTIAL EXPOSURE THROUGH AIR

WITH MAINTENANCE OF A CAP OR IMPLEMENTATION OF A PERMANENT SOIL REMEDY, THERE IS NO SIGNIFICANT EXPOSURE TO CHROMIUM, ARSENIC, AND COPPER THROUGH AIR. SINCE THERE IS NO SIGNIFICANT EXPOSURE, THE RISK OF ADVERSE HEALTH EFFECTS ASSOCIATED WITH MIGRATION OF CHROMIUM THROUGH AIR IS BELIEVED TO BE INSIGNIFICANT.

6.4.2 POTENTIAL EXPOSURE THROUGH DIRECT CONTACT WITH SOIL

AS DESCRIBED IN SECTION 6.1.2, BECAUSE OF SURFACE PAVING OVER SOILS CONTAINING ELEVATED CHROMIUM CONCENTRATIONS, THERE IS NO DIRECT EXPOSURE TO CONTAMINATED SOIL. THEREFORE, THERE IS NO RISK OF ADVERSE HEALTH EFFECTS ASSOCIATED WITH THIS PATHWAY UNDER PRESENT CONDITIONS. HOWEVER, DURING POST-CLOSURE SOIL REMEDIATION, POTENTIAL EXPOSURE IS LIKELY. SUCH EXPOSURE MUST BE ADDRESSED BY IMPLEMENTATION OF AN APPROPRIATE HEALTH AND SAFETY PLAN.

6.4.3 POTENTIAL EXPOSURE THROUGH SURFACE WATER

STORM WATER RUNOFF ORIGINATING FROM THE SITE IS SUBJECT TO INFILTRATION AND DILUTION BY DOWNSTREAM FLOWS. POTENTIAL EXPOSURE MECHANISMS, THEREFORE, INCLUDE EXPOSURE TO GROUND WATER RECHARGED BY INFILTRATING SURFACE WATERS AND DIRECT EXPOSURE TO CONTAMINATED SURFACE WATER. THE FIRST EXPOSURE MECHANISM IS BELIEVED TO BE INSIGNIFICANT BECAUSE OF THE INTERMITTENT NATURE OF THE RUNOFF AND ATTENUATION OF CHROMIUM AND ARSENIC CONCENTRATIONS DURING DOWNWARD PERCOLATION. THE SECOND EXPOSURE MECHANISM MUST CONSIDER THE IMPACT OF DILUTION ON CHROMIUM CONCENTRATIONS WITHIN THE SURFACE DRAINAGE DITCHES.

SITE IMPROVEMENTS AND IMPLEMENTATION OF SURFACE RUNOFF CONTROL MEASURES HAVE REDUCED THE CONCENTRATION OF CHROMIUM AT THE COMPLIANCE POINT (MONITORING STATION C-100) TO ACCEPTABLE LEVELS (LESS THAN 0.05 MG/L). ADDITIONAL SURFACE WATER CONTROLS, IDENTIFIED IN SECTION 7.2.1, SHALL BE IMPLEMENTED TO FURTHER REDUCE THE EXPOSURE THROUGH SURFACE WATER. THE MOST RECENT DATA HAVE SHOWN LESS THAN 0.32 MG/L AND 0.004 MG/L CONCENTRATIONS FOR CHROMIUM AND ARSENIC, RESPECTIVELY, AT STATION C-100. UNDER SUCH CIRCUMSTANCES, THE POTENTIAL EXPOSURE OF BIOLOGICAL RECEPTORS IN DOWNSTREAM DITCHES AND STREAMS IS NEGLIGIBLE.

ALTHOUGH NO FLOW MEASUREMENTS HAVE BEEN MADE IN THE DITCHES DOWNSTREAM OF THE CWP SITE, BASED ON FIELD OBSERVATIONS, AN APPROXIMATE DILUTION FACTOR CAN BE CALCULATED. ACCORDING TO CWP, THE FLOW RATE AT MONITORING STATION C-100 IS TWICE THAT AT STATION NE DUE TO THE CONTRIBUTION FROM OTHER CULVERTS AND STREAMS. AS SHOWN BELOW, A COMPARISON OF WATER QUALITY DATA BETWEEN THESE TWO MONITORING STATIONS SUPPORTS THE ABOVE OBSERVATION.

CHROMIUM CONCENTRATION (MG/1)

DATE	MONITORING STATION NE	MONITORING STATION C-100
APRIL 6, 1986	0.14	0.09
MARCH 5, 1987	0.06	0.03

THE ABOVE DATA SHOW THAT THE CHROMIUM CONCENTRATIONS AT MONITORING STATION C-100 ARE ABOUT 50 PERCENT OF THOSE DETECTED AT MONITORING STATION NE. THE DISTANCE BETWEEN MONITORING STATIONS NE AND C-100 IS ABOUT 550 FEET. IT IS EVIDENT THAT IF FLOW RATES INCREASE AT SUCH PROPORTIONS IN THE DOWNSTREAM DIRECTION AND NO CHROMIUM IS INTRODUCED ALONG THE FLOW PATH, THE CHROMIUM CONCENTRATION WILL NOT EXCEED 0.05 MG/L WITHIN A SHORT DISTANCE FROM MONITORING STATION C-100, IF WASTE DISCHARGE REQUIREMENTS ARE OBSERVED. UNDER SUCH CONDITIONS, THE IMPACT OF CHROMIUM ON DOWNSTREAM RECEPTORS WOULD BE INSIGNIFICANT. TO PROVIDE A MORE QUANTITATIVE ASSESSMENT OF RISK, FLOW RATES MUST BE KNOWN TO ESTIMATE THE DILUTION FACTORS AND THE CONSEQUENT POTENTIAL IMPACT.

THE MINIMUM FLOW IN THE RUSSIAN RIVER IS MAINTAINED AT 150 CFS (DWR, MAY 1980) UNDER INTENSE RAINFALL CONDITIONS, WHEN STORM WATER FLOWS TO THE RUSSIAN RIVER, THE VOLUME ORIGINATING FROM THE SITE IS ASSUMED TO BE 1 PERCENT OF THE FLOW IN THE RIVER. WITH SUCH AN ASSUMPTION, A DILUTION FACTOR OF 100 WOULD BE APPLICABLE FOR CALCULATING THE CHROMIUM CONCENTRATIONS IN THE RIVER. THEREFORE, THE STORM WATER EVENTS, WITH HISTORICAL CONCENTRATIONS OF CHROMIUM, ARE NOT LIKELY TO HAVE AN ADVERSE IMPACT ON SURFACE WATER QUALITY IN THE RUSSIAN RIVER. A MAXIMUM CONCENTRATION OF 0.63 MG/L (APPENDIX C) AT THE SITE WOULD RESULT IN A CONCENTRATION OF 0.0064 MG/L IN THE RIVER. THUS, THE RISK ASSOCIATED WITH THIS POTENTIAL EXPOSURE IS INSIGNIFICANT.

6.4.4 POTENTIAL EXPOSURE THROUGH GROUND WATER

POTENTIAL EXPOSURE THROUGH GROUND WATER HAS BEEN EVALUATED CONSIDERING ON-SITE AND OFF-SITE AREAS SEPARATELY. POTENTIAL EXPOSURE TO ON-SITE GROUND WATER WILL ONLY BE POSSIBLE DURING MONITORING OR ACTIVITIES RELATED TO GROUND WATER EXTRACTION AND TREATMENT. THIS EXPOSURE POTENTIAL MUST BE ELIMINATED BY FOLLOWING THE APPROPRIATE HEALTH AND SAFETY MEASURES AND OTHER STANDARD PROCEDURES OUTLINED IN THIS RAP, THE STORM WATER/GROUND WATER MONITORING PROTOCOL, AND OTHER PERTINENT DOCUMENTS. AS THERE ARE NO ON-SITE WELLS PRODUCING WATER FROM THE CONTAMINATED ZONE, THERE IS NO EXPOSURE AND, THUS, NO RISK.

AS DESCRIBED IN SECTION 4.5.3, THE CURRENT UNDERSTANDING OF OFFSITE GROUND WATER QUALITY CONDITIONS INDICATES THAT CR(VI) CONCENTRATIONS ARE BELOW THE DRINKING WATER STANDARD OF 0.05 MG/L. NO WATER-PRODUCING WELLS ARE KNOWN TO EXIST IN AREAS WHERE HISTORIC CHROMIUM CONCENTRATIONS HAVE EXCEEDED THE 0.05 MG/L DRINKING WATER STANDARD. AT THE PRESENT TIME, THEREFORE, THERE IS NOT BELIEVED TO BE A SIGNIFICANT POTENTIAL FOR EXPOSURE THROUGH THIS MIGRATION PATHWAY THIS CONDITION IS EXPECTED TO PERSIST AS LONG AS ON-SITE EXTRACTION FROM WELL HL-7 AND OTHER REMEDIATION MEASURES ARE IN EFFECT.

FAILURE TO CONTAIN THE CHROMIUM PLUME ON SITE COULD RESULT IN THE INTRODUCTION OF CHROMIUM TO GROUND WATER IMMEDIATELY TO THE EAST (DOWNGRADIENT) OF THE SLURRY CUTOFF WALL. THE IMPACT ON DOWNGRADIENT RECEPTORS WILL DEPEND ON THE CONCENTRATION AND PERSISTENCE OF THE SOURCE, AS DEMONSTRATED BY THE TRANSPORT MODEL (APPENDIX E). FOR INSTANCE, AN INITIAL CONCENTRATION OF 1 MG/L IN GROUND WATER TO THE EAST OF THE SLURRY CUTOFF WALL, WITH A SOURCE REDUCTION RATE OF 0.0063 PER DAY, WOULD RESULT IN A CONCENTRATION OF LESS THAN 0.00068 MG/1 AT ABOUT 820 FEET FROM THE SITE. THIS CONCENTRATION IS ABOUT TWO ORDERS OF MAGNITUDE LOWER THAN THE DRINKING WATER STANDARD OF 0.05 MG/L. HOWEVER, PERSISTENCE OF THE 1 MG/L CONCENTRATION MAY RESULT IN GRADUAL DEGRADATION OF WATER QUALITY IN DOWNGRADIENT AREAS. AS MENTIONED IN SECTION 6.1.4, PERSISTENCE OF A 1 MG/L CHROMIUM CONCENTRATION FOR FOUR YEARS AT WELL CWP-8 MAY CAUSE AN INCREASE IN CHROMIUM CONCENTRATIONS TO 0.05 MG/L AT A DISTANCE OF 820 FEET DOWNGRADIENT. TO ELIMINATE THIS POTENTIAL SITUATION, THE RECOMMENDED REMEDIAL ACTION INCLUDES HYDRAULIC CONTROL MEASURES AT WELL CWP-8 (SECTION 7.0). EXTRACTION FROM WELL CWP-8 WOULD CONTAIN THE CHROMIUM PLUME IN THE VICINITY AND WOULD ELIMINATE THE POTENTIAL FOR FURTHER DOWNGRADIENT MIGRATION.

AS MENTIONED IN SECTION 7.0, A CONTINGENCY PLAN HAS BEEN DEVELOPED FOR POSSIBLE OFF-SITE REMEDIATION. THE PLAN WILL BE IMPLEMENTED SUBSEQUENT TO THE REGULATORY AGENCIES' DECISION REGARDING THE CRITERIA FOR INITIATION OF OFF-SITE REMEDIATION. THE CRITERIA WOULD INCLUDE A PRESCRIBED CHROMIUM CONCENTRATION PERSISTING FOR A GIVEN TIME PERIOD. IMPLEMENTATION OF THE CONTINGENCY PLAN WILL PROVIDE ADDITIONAL CONTROL TO PREVENT FURTHER DOWNGRADIENT MIGRATION.

BASED ON THE ABOVE CONSIDERATIONS, IT IS CONCLUDED THAT UNDER PRESENT CONDITIONS AND WITH CONTINUED ON-SITE REMEDIATION, THERE IS NO POTENTIAL EXPOSURE TO CHROMIUM THROUGH GROUND WATER. THEREFORE, THERE IS NO HEALTH RISK ASSOCIATED WITH THIS PATHWAY.

#ERA

7.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES

THE PURPOSE OF EVALUATING VARIOUS REMEDIAL ACTIONS IS TO SELECT AN ENVIRONMENTALLY ACCEPTABLE AND TECHNICALLY/ECONOMICALLY FEASIBLE ALTERNATIVE FOR IMPLEMENTATION. THIS EVALUATION CONSIDERS VIABLE REMEDIAL TECHNOLOGIES TO ADDRESS SOIL AND GROUND WATER CONTAMINATION AT THE CWP SITE. THE EVALUATION HAS BEEN PERFORMED ACCORDING TO THE PROCEDURE OUTLINED BY THE EPA IN A DOCUMENT ENTITLED "GUIDANCE ON FEASIBILITY STUDIES UNDER CERCLA" (US EPA, JUNE 1985B).

SECTION 7.1 PRESENTS AN EVALUATION OF THE VARIOUS REMEDIAL TECHNOLOGIES CONSIDERED. THOSE SELECTED FOR IMPLEMENTATION, BASED ON TECHNICAL, ENVIRONMENTAL, AND COST CONSIDERATIONS, ARE DESCRIBED IN SECTION 7.2. THE RATIONALE FOR SELECTING THE RECOMMENDED ALTERNATIVE AND REJECTING THE OTHERS IS PRESENTED IN SECTION 7.3. THE ENVIRONMENTAL EFFECTS OF THE RECOMMENDED ALTERNATIVE AND THE APPLICABLE LAWS AND REGULATIONS ARE PRESENTED IN SECTIONS 7.4 AND 7.5.

AS DESCRIBED IN SECTION 5.0, A NUMBER OF INTERIM REMEDIAL MEASURES HAVE BEEN IMPLEMENTED IN THE COURSE OF THE REMEDIAL INVESTIGATIONS AT THE SITE. THEREFORE, IN THE EVALUATION OF REMEDIAL ACTION ALTERNATIVES, THE INTERIM REMEDIAL ACTIONS ALREADY IMPLEMENTED HAVE BEEN CONSIDERED.

7.1 ALTERNATIVE REMEDIAL ACTIONS

REMEDIAL ALTERNATIVES MAY BE CATEGORIZED AS PERTAINING TO SOURCE CONTROL OR MANAGEMENT OF MIGRATION (US EPA, JUNE 1985A). FOR THE CWP SITE, SOURCE CONTROL REFERS TO THE CONTROL OF CONTAMINATED SOIL TO REDUCE OR PREVENT INTRODUCTION OF THE CONTAMINANTS TO GROUND WATER. MANAGEMENT OF MIGRATION REFERS TO CONTAINMENT OF THE CHROMIUM PLUME AND REMEDIATION OF THE IMPACTED WATER-BEARING ZONE.

THE TECHNOLOGIES EVALUATED TO ADDRESS SOIL AND GROUND WATER CONTAMINATION RANGE FROM COMPLETE REMEDIATION TO NO ACTION. THE EVALUATION OF VIABLE OPTIONS TO ADDRESS CONTAMINATED SOIL IS PRESENTED IN SECTION 7.1.1. REMEDIATION OF CONTAMINATED SOILS WILL OCCUR AT THE TIME OF CLOSURE OF THE FACILITY. THE CLOSURE OF THE FACILITY IS PROJECTED TO OCCUR IN 10 YEARS. A TRUST FUND WILL BE ESTABLISHED (SECTION 9.0) TO FUND FUTURE REMEDIATION OF SOILS. TREATABILITY STUDIES WILL BE CONDUCTED PRIOR TO SELECTING THE FINAL SOILS REMEDY AT THE TIME OF CLOSURE OF THE FACILITY. THE EVALUATION OF THE TECHNOLOGIES AVAILABLE TO ADDRESS GROUND WATER CONTAMINATION IS PRESENTED IN SECTION 7.1.2. AS EXTRACTION IS A VIABLE OPTION FOR THE REMEDIATION OF GROUND WATER CONTAMINATION, ALTERNATIVE METHODS OF GROUND WATER TREATMENT HAVE ALSO BEEN EVALUATED. THIS EVALUATION IS PRESENTED IN SECTION 7.1.3. THE OPTIONS FOR THE DISCHARGE OF TREATED GROUND WATER ARE EVALUATED IN SECTION 7.1.4.

7.1.1 CONTROL OF CONTAMINATED SOIL

PREVIOUS INVESTIGATIONS HAVE DELINEATED THE AREAL EXTENT OF SOILS CONTAINING ELEVATED CONCENTRATIONS OF CHROMIUM AND ARSENIC. VERTICALLY, SOILS CONTAINING OVER 100 MG/KG OF CHROMIUM AND ARSENIC ABOVE BACKGROUND LEVEL (15 MG/KG) OCCUR PREDOMINANTLY WITHIN THE UPPER 1 FOOT OF THE SOIL PROFILE. MOST SOIL SAMPLES COLLECTED BELOW A DEPTH OF 1 FOOT CONTAIN LESS THAN 50 MG/KG OF TOTAL CHROMIUM AND ARSENIC CONCENTRATIONS IN THE RANGE OF BACKGROUND LEVELS. MORE SPECIFICALLY, OF THE 25 SOIL SAMPLES COLLECTED FROM THE 3-FOOT DEPTH, ONLY 5 CONTAINED MORE THAN 50 MG/KG OF TOTAL CHROMIUM AND NONE CONTAINED MORE THAN 100 MG/KG. THE FOUR 3-FOOT SAMPLES CONTAINING OVER 50 MG/KG WERE FROM BORINGS S-2, S-4, S-6, S-12, S-14, AND S-23, WHICH ARE SPATIALLY DISTRIBUTED ACROSS THE SITE AND DO NOT INDICATE A SINGLE SOURCE SUCH AS THE RETORTS ON TREATED WOOD STORAGE AREAS. IN PARTICULAR, IT IS NOTED THAT BORING S-23 IS LOCATED OFF SITE, ACROSS TAYLOR DRIVE. THE DISTRIBUTION OF ELEVATED TOTAL CHROMIUM CONCENTRATIONS, I.E. GREATER THAN MG/KG, AT DEPTHS OF 6 AND 10 FEET BELOW GRADE IS SIMILAR TO THAT DESCRIBED ABOVE AT THE 3-FOOT DEPTH. ACCORDINGLY, THE AREAL DISTRIBUTION OF TOTAL CHROMIUM IS BEST REPRESENTED BY ISOCONCENTRATIONS AT THE 1-FOOT DEPTH. THE APPROXIMATE DISTRIBUTION OF SOILS CONTAINING OVER 100 MG/KG OF CHROMIUM AT THE 1-FOOT DEPTH IS SHOWN IN FIGURE 11. THIS DELINEATION OF CHROMIUM DISTRIBUTION AND OTHER PERTINENT REMEDIAL INVESTIGATION FINDINGS (SECTION 4.0) HAVE BEEN USED AS A BASIS FOR DEVELOPING AND EVALUATING VARIOUS REMEDIAL TECHNOLOGIES. THE POTENTIAL REMEDIAL TECHNOLOGIE CONSIDERED FOR CONTROL OF THE CONTAMINATED SOIL INCLUDE:

- SOIL REMOVAL AND OFF-SITE DISPOSAL
- SOIL REMOVAL AND ON-SITE TREATMENT
- IN-SITU TREATMENT
- PARTIAL EXCAVATION
- CONTAINMENT
- NO ACTION.

7.1.1.1 SOIL REMOVAL AND OFF-SITE DISPOSAL

THIS TECHNOLOGY CONSIDERS REMOVAL AND OFF-SITE DISPOSAL OF SOIL IN WHICH THE CHROMIUM CONCENTRATION IS ABOVE 100 MG/KG AND THE ARSENIC CONCENTRATION IS ABOVE 15 MG/KG. THE CONCENTRATION FOR CHROMIUM HAS BEEN SELECTED ON THE BASIS OF THE PREVIOUS SOIL QUALITY CHARACTERIZATION WHICH DEMONSTRATED THAT 100 MG/L MAY BE CONSIDERED TO BE DEFINITELY ABOVE BACKGROUND LEVELS. BASED ON THE 100 MG/KG TOTAL CHROMIUM ISOCONCENTRATION SHOWN IN FIGURE 11, THE AREA OF CONCERN IS ESTIMATED TO BE ABOUT 69,800 FT2 OR 1.60 ACRES. TO ESTIMATE THE VOLUME OF CONTAMINATED SOIL, IT HAS BEEN ASSUMED THAT THE SOIL IS UNIFORMLY CONTAMINATED TO AN AVERAGE DEPTH OF 1.5 FEET BELOW GRADE. BASED ON THIS ASSUMPTION, THE VOLUME OF CONTAMINATED SOIL WOULD BE APPROXIMATELY 3,880 CUBIC YARDS. IT SHOULD BE NOTED THAT IN CERTAIN AREAS, SUCH AS THE MAIN PROCESS AREA, THE DEPTH OF CONTAMINATION MAY BE GREATER. ACCORDINGLY, IN THE ABSENCE OF ANY OTHER DATA, IT HAS BEEN ASSUMED THAT THE AREA BENEATH THE RETORTS AND THE RAIL LINES, MEASURING ABOUT 50 FEET BY 280 FEET, IS CONTAMINATED WITH MORE THAN 100 MG/KG TOTAL CHROMIUM AND MORE THAN 15 MG/KG ARSENIC TO AN AVERAGE DEPTH OF 5 FEET BELOW GRADE. THE ADDITIONAL VOLUME WITHIN THIS ARBITRARY ZONE IS 1,890 CUBIC YARDS. THE ESTIMATED TOTAL VOLUME OF SOIL CONTAINING 100 MG/KG OR MORE OF TOTAL CHROMIUM IS ESTIMATED TO BE 5,770 CUBIC YARDS.

TYPICALLY, SOIL EXCAVATION TO A DEPTH OF 1 TO 2 FEET WOULD BE PERFORMED BY DOZERS AND THE SOIL LOADED ONTO TRUCKS AND TRANSPORTED TO A LICENSED HAZARDOUS WASTE FACILITY APPROVED BY THE EPA AND IN ACCORDANCE WITH APPLICABLE SARA REQUIREMENTS. THE NEAREST OPERATING FACILITY TO THE SITE IS IN KETTLEMAN CITY, LOCATED IN CENTRAL CALIFORNIA.

COMPLETE REMOVAL OF CONTAMINATED SOIL, TO THE LIMITS SHOWN IN FIGURE 11, WOULD REQUIRE THE CESSATION OF WOOD PRESERVING OPERATIONS AND THE REMOVAL OF THE WOOD PRESERVING FACILITIES. THEREFORE, IT HAS BEEN ASSUMED THAT ANY SUCH REMEDIATION WOULD OCCUR SUBSEQUENT TO THE CLOSURE OF THE CWP OPERATION. THE ESTIMATED COST FOR REMOVAL AND OFF-SITE DISPOSAL OF 5,770 CUBIC YARDS OF SOIL IS PRESENTED IN TABLE 12.

7.1.1.2 SOIL REMOVAL AND ON-SITE TREATMENT

THIS ALTERNATIVE INCLUDES EXCAVATION AND REMOVAL OF SOIL, FOLLOWED BY ON-SITE TREATMENT. ON-SITE TREATMENT MAY INVOLVE THE USE OF ORGANIC OR INORGANIC POLYMERS WHICH HAVE THE CAPABILITY OF BINDING THE METALS, MAKING THEM LESS SUSCEPTIBLE TO LEACHING. THESE TECHNOLOGIES HAVE NOT BEEN TESTED AT FIELD SCALE; THUS, IT IS NOT KNOWN HOW APPLICABLE THEY MAY BE TO THE CWP SITE. TO REALISTICALLY EVALUATE ON-SITE TREATMENT AS A REMEDIAL OPTION FOR CONTAMINATED SOIL, LABORATORY AND FIELD TESTS ARE NEEDED. NORMALLY, A NUMBER OF PRODUCTS ARE TESTED TO ASSESS THEIR FIXATION POTENTIAL. THE FIXATION POTENTIAL IS DETERMINED BY EVALUATING THE LEACHING BEHAVIOR OF THE SOIL PRIOR TO AND AFTER TREATMENT. IF LABORATORY TESTS INDICATE THAT A PARTICULAR TREATMENT IS ACCEPTABLE IN TERMS OF LEACHING, A PILOT TEST IS GENERALLY PERFORMED TO ASSESS THE APPLICABILITY OF THE TECHNOLOGY TO FIELD CONDITIONS. IF THE PILOT TEST DEMONSTRATES THAT THE METHOD IS APPLICABLE TO FIELD-SCALE REMEDIATION, A DETAILED DESIGN IS PREPARED. GEOSYSTEM'S EXPERIENCE IN SIMILAR PROJECTS SHOWS THAT ON-SITE TREATMENT IS FEASIBLE.

FOR COST ESTIMATING PURPOSES, IT HAS BEEN ASSUMED THAT ON-SITE TREATMENT IS A FEASIBLE REMEDIAL OPTION. IT IS NOTED, HOWEVER, THAT DESPITE THE AVOIDANCE OF THE HIGH COST OF OFF-SITE DISPOSAL, THE ESTIMATED COST OF ON-SITE TREATMENT IS STILL RELATIVELY HIGH. THIS IS DUE PRIMARILY TO THE DURATION OF IMPLEMENTATION. THE ESTIMATED COSTS ASSOCIATED WITH EXCAVATION AND ON-SITE TREATMENT ARE SHOWN IN TABLE 12.

7.1.1.3 IN-SITU TREATMENT

THIS OPTION INCLUDES IN-SITU PHYSICAL AND/OR CHEMICAL TREATMENT TO FIX THE CHROMIUM AND ARSENIC IN SOIL TO THE EXTENT THAT IT WOULD NOT ACT AS A SOURCE TO GROUND WATER CONTAMINATION. THE SIMPLEST IN-SITU TREATMENT METHOD WOULD BE LEACHING THE SOIL WITH WATER AND EXTRACTING AND TREATING THE LEACHATE. IF THIS METHOD WERE CHOSEN, THE PAVEMENT WOULD HAVE TO BE REMOVED TO

ALLOW WATER TO PERCOLATE THROUGH THE CONTAMINATED SOIL AND LEACH THE CHROMIUM.

PREVIOUS LABORATORY LEACHABILITY STUDIES (IT/D'APPOLONIA, MAY 1984) HAVE SHOWN THAT UNDER ACIDIC CONDITIONS (PH = 5.0), A MAXIMUM OF 2.8 PERCENT CHROMIUM IS RECOVERABLE. THESE RESULTS HAVE ALSO INDICATED THAT MOST OF THE CHROMIUM IN THE SOIL IS IN THE CR(III) FORM. THE TRIVALENT FORMS OF CHROMIUM ARE MORE STABLE, LESS SOLUBLE, AND LESS MOBILE THAN THE HEXAVALENT FORMS. THEREFORE, IF IN-SITU LEACHING WAS PERFORMED WITH A NEUTRAL PH SOLUTION (WATER), LOWER CHROMIUM RECOVERY WOULD BE EXPECTED. CONSIDERING THE LEACHING CHARACTERISTICS OF TRIVALENT CHROMIUM AND OPERATIONAL CONSTRAINTS, IN-SITU LEACHING DOES NOT APPEAR TO BE AN EFFICIENT MEANS OF REMEDIATION.

OTHER OPTIONS INCLUDE INJECTION OF COMPOUNDS INTO THE SOIL TO CHEMICALLY FIX THE CHROMIUM AND ARSENIC IN SOIL. THIS OPTION IS GENERALLY MORE EFFECTIVE IN HOMOGENEOUS, SATURATED AQUIFER SYSTEMS OF HIGH PERMEABILITY. GIVEN THE COMPLEX STRATIGRAPHY AND DISCONTINUITY OF PERMEABLE STRATA AT THE SITE, THIS TYPE OF IN-SITU TREATMENT IS JUDGED TO BE INEFFECTIVE AND HAS NOT BEEN CONSIDERED FURTHER.

7.1.1.4 PARTIAL EXCAVATION AND OFF-SITE DISPOSAL

PARTIAL EXCAVATION IS ANOTHER VIABLE ALTERNATIVE TO CONTROL CONTAMINATED SOIL AT THE SITE. BASED ON PREVIOUS SITE INVESTIGATIONS, THE AREAS OF SOIL CONTAINING MORE THAN 130 MG/KG OF CHROMIUM AND 15 MG/KG OF ARSENIC HAVE BEEN IDENTIFIED IN FIGURE 11 OF THE D'APPOLONIA (1984) REPORT. THESE AREAS CENTER AROUND BORINGS S-4, S-5, AND S-8 AND SAMPLING LOCATIONS G-5, G-10, AND G-11. THE LOCATIONS OF THESE BORINGS AND SAMPLING LOCATIONS ARE SHOWN IN FIGURE 11. THE 130 MG/KG CR CONCENTRATION WAS CHOSEN BECAUSE IT ENABLED AREAS WITHIN THE 100 MG/KG SOIL CONTAMINATION BOUNDARY TO BE ADDRESSED WITHOUT COMPLETE SOIL REMOVAL. IT IS NOTED THAT THE AREAL EXTENT OF ARSENIC CONTAMINATION GENERALLY COINCIDES WITH THAT OF CHROMIUM (FIGURE 11). BASED ON A DEPTH OF CONTAMINATION OF 2 FEET, PARTIAL EXCAVATION WOULD RESULT IN AN ESTIMATED SOIL VOLUME OF ABOUT 3,300 CUBIC YARDS. THE ESTIMATED COSTS ASSOCIATED WITH IMPLEMENTATION OF THIS OPTION ARE SUMMARIZED IN TABLE 12.

7.1.1.5 CONTAINMENT

THE SIMPLEST METHOD OF CONTAINMENT IS TO PROVIDE SURFACE PAVING OVER THE AREAS KNOWN TO CONTAIN GREATER THAN 100 MG/KG OF CHROMIUM AND 15 MG/KG OF ARSENIC. THE SURFACE PAVING OR CAPPING WOULD PREVENT INFILTRATION OF SURFACE WATER THROUGH THE CONTAMINATED SOIL AND CONSEQUENTLY MINIMIZE OR ELIMINATE THE LEACHING OF CHROMIUM INTO GROUND WATER. SURFACE PAVING HAS BEEN INSTALLED AT THE SITE IN VARIOUS PHASES SINCE 1979. THE PRESENT EXTENT OF SURFACE PAVING IS SHOWN IN FIGURE 2. COMPARISON WITH THE AREA OF NEAR-SURFACE SOIL CONTAMINATION DEMONSTRATES THAT THE LARGE MAJORITY OF CHROMIUM-CONTAINING SOILS ARE LOCATED BENEATH THE PAVED AREA. MAINTENANCE OF THE INTEGRITY OF THE EXISTING CAP IS AN ESSENTIAL COMPONENT OF EFFECTIVE CONTAINMENT PRIOR TO IMPLEMENTATION OF A PERMANENT REMEDY. APPROXIMATELY 3 PERCENT OF THE CONTAMINATED SOIL AREA IS NOT CURRENTLY PAVED. RECOMMENDATIONS CONCERNING THESE REMAINING UNPAVED AREAS ARE PRESENTED IN SECTION 7.2.

OTHER METHODS OF CONTAINMENT INCLUDE PHYSICAL BARRIERS, SUCH AS SLURRY, SHEET PILE, OR CHEMICAL GROUT CUTOFF WALLS; OR HYDRAULIC BARRIERS, SUCH AS EXTRACTION/INJECTION SYSTEMS. THESE OPTIONS ARE ADDRESSED FURTHER IN RELATION TO PLUME CONTROL IN SECTION 7.1.2.

7.1.1.6 NO ACTION

THIS OPTION ALLOWS THE CONTAMINATED SOIL TO REMAIN IN PLACE, UNREMEDIATED. IMPLEMENTATION OF THE NO ACTION OPTION IS TYPICALLY COMBINED WITH OTHER CONTROL MEASURES IF GROUND WATER CONTAMINATION IS OF CONCERN. ALSO, THE NO ACTION OPTION REQUIRES EXTENSIVE MONITORING TO EVALUATE THE POTENTIAL IMPACT OF RESIDUAL SOIL CONTAMINATION ON THE ENVIRONMENT. GROUND WATER MONITORING DATA, GENERATED SINCE 1981, HAVE INDICATED SOME IMPROVEMENT IN WATER QUALITY, PRIMARILY IN OFF-SITE AREAS. APPLICATION OF THE NO ACTION ALTERNATIVE TO THE ENTIRE SITE WOULD, HOWEVER, REQUIRE FURTHER EVALUATION OF THE POTENTIAL IMPACT ON GROUND WATER QUALITY AND THE ENVIRONMENT, AS DESCRIBED IN SECTION 7.3.

7.1.2 PLUME CONTROL

PLUME CONTROL MEASURES WOULD BE DESIGNED TO LIMIT THE MIGRATION OF THE DISSOLVED CONSTITUENTS WHILE GRADUALLY REMEDIATING EXISTING CONTAMINATION. THE ALTERNATIVES CONSIDERED FOR SCREENING

ARE AS FOLLOWS:

- PHYSICAL CONTAINMENT
- IN-SITU TREATMENT
- HYDRAULIC CONTROL
- ELECTROKINETIC TREATMENT
- NO ACTION.

7.1.2.1 PHYSICAL CONTAINMENT

PHYSICAL CONTAINMENT MEASURES INCLUDE SLURRY CUTOFF WALLS, SHEET PILES, AND GROUT CURTAINS. THE MOST COMMON METHOD OF PHYSICAL CONTAINMENT FOR PLUME CONTROL IS THE CONSTRUCTION OF SLURRY CUTOFF WALLS. THIS OPTION, PER SE, DOES NOT REMEDIATE THE AQUIFER; HOWEVER, THE CONTAMINANTS ARE CONTAINED. A SLURRY CUTOFF WALL IS CONSTRUCTED BY EXCAVATING A CONTINUOUS, NARROW TRENCH WHICH IS KEPT FILLED WITH BENTONITE SLURRY TO STABILIZE THE SIDES OF THE EXCAVATION. THE TRENCH IS BACKFILLED WITH A MIXTURE OF EXCAVATED SOIL AND BENTONITE AS TRENCHING PROGRESSES. BACKFILLING DISPLACES THE SLURRY, WHICH IS RECYCLED. THE SLURRY WALL ACTS AS A BARRIER TO LATERAL GROUND WATER FLOW IF THE ZONE OF CONTAMINATION IS COMPLETELY CONTAINED. OTHERWISE, HYDRAULIC CONTROL MUST BE INITIATED TO PROVIDE ADEQUATE CONTAINMENT. FLOW BENEATH THE WALL IS RESTRICTED BY EITHER KEYING THE WALL INTO A LOW PERMEABILITY STRATUM OR BY HYDRAULIC CONTROL. AS DISCUSSED IN SECTION 5.2, THIS OPTION HAS BEEN IMPLEMENTED AS AN INTERIM REMEDIAL MEASURE BY CWP. OTHER PHYSICAL CONTAINMENT MEASURES, SUCH AS SHEET PILES AND GROUT CURTAINS, HAVE NOT, THEREFORE, BEEN CONSIDERED FURTHER.

7.1.2.2 IN-SITU TREATMENT

THIS TECHNOLOGY INVOLVES THE PASSAGE OF A TREATMENT AGENT THROUGH THE CONTAMINATED AQUIFER, USUALLY BY PUMPING AND/OR INJECTION.

THE EFFECTIVENESS OF THIS OPTION DEPENDS PRIMARILY ON THE PERMEABILITY OF THE CONTAMINATED MEDIUM, THE CONTINUITY OF THE WATER-BEARING ZONE, AND THE DEGREE OF BONDING OF CHROMIUM TO SOIL PARTICLES. IN-SITU TREATMENT BY THIS METHOD IS NOT A PROVEN TECHNOLOGY, PARTICULARLY IF CONSIDERED FOR APPLICATION TO CHROMIUM FIXATION IN LARGE AREAS. RESEARCH RELATED TO APPLICATION OF THIS TECHNOLOGY IS UNDERWAY, AND IF FUTURE DATA SHOW PROMISING RESULTS, ITS APPLICATION TO THE CWP SITE COULD BE RECONSIDERED. AT THIS TIME, HOWEVER, IN-SITU TREATMENT BY CHEMICAL FIXATION HAS NOT BEEN CONSIDERED FURTHER.

7.1.2.3 HYDRAULIC CONTROL

HYDRAULIC CONTROL IS AN ACCEPTED AND WELL DOCUMENTED METHOD OF PLUME CONTROL AND AQUIFER REMEDIATION. THIS OPTION INCLUDES EXTRACTION AND/OR INJECTION IN ORDER TO PRODUCE A ZONE OF INFLUENCE BEYOND WHICH THERE WILL NOT BE SIGNIFICANT MIGRATION OF CONTAMINANTS. EXTRACTED GROUND WATER IS REPLENISHED BY CONTAMINANT-FREE GROUND WATER, RESULTING IN A GRADUAL REDUCTION IN CHROMIUM CONCENTRATIONS.

CONSIDERING THE CHROMIUM ISOCONCENTRATIONS SHOWN IN FIGURES 12, 13, AND 14, THE APPLICATION OF HYDRAULIC CONTROL IS BELIEVED TO BE RELEVANT TO THE FOLLOWING GEOGRAPHIC AREAS:

- NEAR THE RETORTS
- NEAR THE EASTERN SITE BOUNDARY
- OFF SITE TO THE SOUTHEAST.

THE GROUND WATER QUALITY DATA HAVE SHOWN THAT CHROMIUM CONCENTRATIONS ARE HIGHER IN ZONE 1 IN THE RETORT AREA THAN IN OTHER LOCATIONS. TO PREVENT CHROMIUM MIGRATION FROM THE RETORT AREA TO DOWNGRADIENT LOCATIONS, INTERCEPTION OF THE PLUME BY TRENCHES OR LARGE DIAMETER RECOVERY WELLS HAS BEEN CONSIDERED. BOTH OF THESE METHODS COULD PROVIDE A BARRIER TO CHROMIUM MIGRATION WITHIN THEIR RESPECTIVE RADII OF INFLUENCE. TRENCHES ARE TYPICALLY MORE EFFECTIVE WATER-BEARING ZONES WHICH ARE NOT VERY CONDUCTIVE AND LACK HYDRAULIC CONTINUITY; HOWEVER, THE PRESENCE OF WOOD PRESERVING FACILITIES IN THE RETORT AREA PRECLUDES THE INSTALLATION OF A TRENCH. AS DESCRIBED IN SECTION 5.3, A LARGE-DIAMETER RECOVERY WELL, WELL CWP-18, WAS INSTALLED NEAR THE RETORT AREA AS AN INTERIM REMEDIAL MEASURE.

PLUME CONTROL NEAR THE EASTERN SITE BOUNDARY HAS ALSO BEEN CONSIDERED IN ORDER TO PREVENT

OFF-SITE MIGRATION. AS DESCRIBED IN SECTION 5.2, THIS OPTION INCLUDES EXTRACTION FROM WELL HL-7 AND HAS BEEN IMPLEMENTED AS AN INTERIM REMEDIAL MEASURE. IN ADDITION TO EXTRACTION FROM WELL HL-7, PUMPING FROM THE DOWNGRADIENT SIDE OF THE SLURRY WALL WOULD CONTAIN ANY CONTAMINATION WHICH MAY HAVE PASSED THE BARRIER AND ACTS AS A SOURCE OF OFF-SITE CONTAMINATION:

OFF-SITE REMEDIATION HAS BEEN CONSIDERED BECAUSE OF THE PRESENCE OF CHROMIUM IN SOME OFF-SITE WELLS IN THE PAST. OFF-SITE REMEDIATION HAS BEEN EVALUATED IN SOME DETAIL (GEOSYSTEM, APRIL 1987) AND IS NOT BELIEVED TO BE NECESSARY AT THIS TIME. THIS JUDGEMENT IS BASED ON CURRENT GROUND WATER QUALITY AND THE TREND OF IMPROVING WATER QUALITY IN OFF-SITE AREAS AS A RESULT OF THE INTERIM REMEDIAL MEASURES IMPLEMENTED NEAR THE EASTERN SITE BOUNDARY. IT SHOULD BE NOTED, HOWEVER, THAT FUTURE MONITORING AND NEW REGULATIONS MAY DICTATE RECONSIDERATION OF OFF-SITE REMEDIATION.

HYDRAULIC CONTROL MEASURES WHICH INVOLVE THE EXTRACTION OF CONTAMINATED GROUND WATER REQUIRE AN ENVIRONMENTALLY-ACCEPTABLE AND COST-EFFECTIVE METHOD OF HANDLING THE EXTRACTED WATER. AS PREVIOUSLY MENTIONED, THE MAJORITY OF THE EXTRACTED CHROMIUM CONTAINING WATER IS RECYCLED BACK INTO CWP'S WOOD PRESERVING OPERATIONS; THEREFORE, NO SPECIAL HANDLING IS REQUIRED. EXCESS CONTAMINATED WATER MUST, HOWEVER, BE TREATED PRIOR TO DISCHARGE. SECTION 7.1.3 SUMMARIZES THE ALTERNATIVE TREATMENT PROCESSES CONSIDERED TO ACHIEVE ACCEPTABLE EFFLUENT QUALITY.

7.1.2.4 ELECTROKINETIC PHENOMENA

ELECTROKINETIC PHENOMENA REFERS TO THOSE METHODS BY WHICH MIGRATION OF DISSOLVED CONTAMINANTS IN GROUND WATER IS ENHANCED BY THE APPLICATION OF AN ELECTRIC CURRENT. THE METHODOLOGY IS BASED ON INDUCING ELECTRICAL GRADIENTS TO THE SOIL-ELECTROLYTE-WATER SYSTEM, RESULTING IN DISPLACEMENT OR MIGRATION OF CATIONS AND ANIONS. HISTORICALLY, THIS TECHNOLOGY HAS ACHIEVED SOME DEGREE OF SUCCESS IN INDUCING FLOW IN LOW PERMEABILITY DISPERSIVE SOILS. APPLICATION OF THIS METHOD TO THE REMOVAL OF INORGANIC SPECIES AND DEWATERING HAS BEEN DEMONSTRATED BY A NUMBER OF INVESTIGATIONS (MITCHELL AND ARULANANDAN, 1968; GRAY AND MITCHELL, 1967; MEHRAN, 1971). RECENTLY, THE EPA HAS INITIATED A NUMBER OF PROJECTS TO TEST THE APPLICABILITY OF THIS TECHNOLOGY TO FIELD-SCALE PROBLEMS. AS THIS TECHNOLOGY IS STILL IN THE DEVELOPMENTAL STAGE, HOWEVER, IT HAS NOT BEEN CONSIDERED FURTHER FOR IMPLEMENTATION AT THE CWP SITE.

7.1.2.5 NO ACTION

THIS OPTION ALLOWS THE DISSOLVED CONTAMINANTS TO MIGRATE UNCONTROLLED AND UNREMEDIATED. THIS OPTION WOULD RESULT IN AN EXPANSION OF THE PLUME IN THE DOWNGRADIENT DIRECTION AND WOULD PLACE POTENTIAL BIOLOGICAL RECEPTORS AT RISK.

7.1.3 GROUND WATER TREATMENT TECHNOLOGY ASSESSMENT

AS MENTIONED IN SECTION 5.0, CWP IS ABLE TO UTILIZE EXTRACTED GROUND WATER IN WOOD PRESERVING OPERATIONS AT CERTAIN TIMES OF THE YEAR. WHEN THE SUPPLY OF EXTRACTED GROUND WATER EXCEEDS CWP'S NEEDS, HOWEVER, TREATMENT IS REQUIRED BEFORE DISCHARGE.

THE EVALUATION OF THE VARIOUS GROUND WATER TREATMENT TECHNOLOGIES IS BASED ON A CONTINUOUS EXTRACTION RATE OF 5 TO 20 GPM FOR SEVEN YEARS, A CHROMIUM CONCENTRATION OF LESS THAN 10 MG/L IN THE INFLUENT, AND A REQUIRED EFFLUENT CONCENTRATION OF LESS THAN 0.05 MG/L.

THE TREATMENT TECHNOLOGIES HAVE BEEN SCREENED ON THE BASIS OF THE FOLLOWING TECHNICAL AND ECONOMIC CRITERIA:

- PERFORMANCE AND EFFECTIVENESS OF THE TECHNOLOGY.
- PROJECTED SERVICE LIFE.
- DEMONSTRATED RELIABILITY.
- EASE OF IMPLEMENTATION.
- SAFETY CONSIDERATIONS.
- CAPITAL COSTS.
- OPERATION AND MAINTENANCE COSTS.

THE OPERATION AND MAINTENANCE (O & M) COSTS ARE THOSE POSTCONSTRUCTION COSTS NECESSARY TO MAINTAIN SATISFACTORY OPERATION OF THE TREATMENT SYSTEM AND THE REQUIRED MONITORING (TABLE 13).

THE OBJECTIVE OF THE SCREENING WAS TO ELIMINATE THOSE TECHNOLOGIES THAT HAVE AN ORDER OF MAGNITUDE GREATER COST, BUT DO NOT PROVIDE GREATER ENVIRONMENTAL OR PUBLIC HEALTH BENEFITS OR GREATER RELIABILITY. THE TECHNOLOGIES CONSIDERED FOR SCREENING WERE:

- ELECTROCHEMICAL PROCESS.
- CHEMICAL REDUCTION AND PRECIPITATION.
- CHEMICAL PRECIPITATION WITH SEDIMENTATION OR FILTRATION.
- ACTIVATED CARBON ADSORPTION.
- ION EXCHANGE.
- ELECTRODIALYSIS.

7.1.3.1 ELECTROCHEMICAL PROCESS

THE ELECTROCHEMICAL PROCESS INVOLVES PASSING CHROMIUM-CONTAINING GROUND WATER THROUGH A CELL CONTAINING CONSUMABLE IRON ELECTRODES WHICH, IN THE PRESENCE OF AN ELECTRICAL CURRENT, GENERATE FERROUS AND HYDROXIDE IONS. THESE IONS REACT WITH CHROMATE IONS IN SOLUTION TO PRECIPITATE CHROMIC AND FERRIC HYDROXIDES. THIS PROCESS IS UNIQUE IN THAT NO CHEMICAL ADDITIVES ARE REQUIRED TO GENERATE THE PRECIPITANT. THE ELECTROCHEMICAL OPERATION IS A "ONCE-THROUGH PROCESS" REQUIRING MINIMAL REACTION TIME. THE THEORY OF OPERATION INVOLVES AN OXIDATION-REDUCTION REACTION WHEREBY ELECTRONS ARE SUPPLIED BY AN EXTERNAL ELECTRICAL SOURCE REDUCING THE METAL IONS IN THE ELECTROLYTE TO FORM ELEMENTAL METAL AT THE CATHODE SURFACE. THE EQUIPMENT CONSISTS OF A REACTOR MODULE CONTAINING THE ANODE AND CATHODE ASSEMBLIES AND TWO CONTROLLABLE POWER SUPPLIES. THE DETAILS OF THIS TECHNOLOGY RELATED TO ELECTRODE POTENTIALS, EQUILIBRIUM, OXIDATION-REDUCTION, AND MIXED POTENTIALS, VOLTAMMETRY, AND ELECTROCAPILLARITY CAPACITY HAVE BEEN DESCRIBED IN THE LITERATURE (AHMED, 1979; PEMSLER AND RAPPAS, 1979; AYRES AND FEDKIW, 1983; AND DEAN, ET AL., 1972). MORE SPECIFIC INFORMATION ON OPERATION OF ELECTROCHEMICAL PROCESS UNITS IS PRESENTED IN SECTION 7.2.4.

ELECTROCHEMICAL TREATMENT HAS BEEN USED FOR MANY YEARS IN THE MINING AND UTILITY INDUSTRIES AND IS A PROVEN TECHNOLOGY FOR REMOVING HEXAVALENT CHROMIUM FROM WASTEWATER. THE ELECTROCHEMICAL TREATMENT PROCESS, THEREFORE, IS CAPABLE OF REMOVING HEXAVALENT CHROMIUM FROM GROUND WATER EXTRACTED AT THE CWP SITE. THE SALIENT FEATURES OR THE ELECTROCHEMICAL PROCESS PERTINENT TO THE CWP SITE ARE SUMMARIZED IN TABLE 13. REMOVAL EFFICIENCY OF THE ELECTROCHEMICAL PROCESS FOR CHROMIUM IS DEMONSTRATED IN TABLE 14.

THE ADVANTAGES OF THE ELECTROCHEMICAL PROCESS ARE AS FOLLOWS:

- REDUCES THE CR(VI) CONTENT OF GROUND WATER TO EPA COMPATIBLE LEVELS.
- VERY LOW OPERATING COSTS.
- NO CONSUMABLE REAGENTS REQUIRED FOR OPERATION.
- REQUIRES LITTLE FLOOR SPACE AND OPERATOR ATTENTION.
- ELIMINATES THE CONVENTIONAL CHEMICAL PRECIPITATION PROCESS.

THE OPERATING COSTS FOR ELECTRODE CONSUMPTION, POWER, AND ACID FOR THE ELECTROCHEMICAL UNIT ARE ESTIMATED AT ABOUT 10 CENTS PER 1,000 GALLONS OF GROUND WATER TREATED. AT THE ANTICIPATED FLOW RATE OF 20 GPM, THE OPERATING COSTS AMOUNT TO ABOUT $1,000 ANNUALLY. LABOR AND WASTE DISPOSAL COSTS FOR THE ELECTROCHEMICAL PROCESS ARE ESTIMATED TO BE ABOUT $50 PER DAY.

7.1.3.2 CHEMICAL REDUCTION AND PRECIPITATION

THE MOST CONVENTIONAL METHOD FOR THE REMOVAL OF CHROMIUM IS REDUCTION OF THE HEXAVALENT CHROMIUM TO THE TRIVALENT STATE, FOLLOWED BY PH ADJUSTMENT TO FORM INSOLUBLE CARBONATES OR HYDROXIDES WHICH CAN BE REMOVED AS SLUDGES. SOME COMMON REDUCING AGENTS INCLUDE GASEOUS SULFUR DIOXIDE, SODIUM BISULFITE OR METABISULFITE, AND FERROUS SULFATE. IN THE REDUCTION OF HEXAVALENT CHROMIUM TO TRIVALENT CHROMIUM USING SULFUR DIOXIDE, THE OXIDATION STATE OF CHROMIUM CHANGES FROM +6 TO +3 (CR IS REDUCED) AND THE OXIDIZATION STATE OF SULFUR INCREASES FROM +2 TO +3 (S IS OXIDIZED).

$$2H_2CrO_4 + 3SO_2 + 3H_2O \text{ ---} Cr_2(SO_4)_3 + 5H_2O$$

SULFUR DIOXIDE IS SUPPLIED AS A GAS AND FED INTO THE CHROME REDUCTION TANK AS LIQUID THROUGH A VACUUM EDUCTOR-TYPE OF SULFONATOR. THE SULFONATOR IS CONTROLLED BY AN OXIDATION REDUCTION POTENTIAL (ORP) PROBE MEASURING FREE SULFIDES IN THE CHROME REDUCTION TANK. MIXING IS USUALLY

REQUIRED TO IMPROVE CONTACT BETWEEN THE REDUCTION AGENT AND THE GROUND WATER. REACTION TIMES VARY WITH REDUCING AGENTS, TEMPERATURE, PH, AND CONCENTRATION; HOWEVER, REDUCTION TIMES ARE ON THE ORDER OF MINUTES.

REDUCTION OF HEXAVALENT CHROMIUM REQUIRES PH ADJUSTMENT, NORMALLY WITH SULFURIC ACID, TO A PH OF APPROXIMATELY 2 TO 3. WHEN SULFUR DIOXIDE IS USED AS THE REDUCING AGENT, SULFONATORS MUST BE USED TO COMBINE SULFUR DIOXIDE WITH WATER TO FORM SULFUROUS ACID. THE SULFUROUS ACID REACTS WITH CHROMIUM TO FORM CHROMIC SULFATE. OTHER REDUCING AGENTS ARE ADDED AS SOLIDS OR AS SOLUTIONS. THE CHEMICAL REDUCTION IS FOLLOWED BY ALKALINE ADDITION, WHICH RESULTS IN PRECIPITATION OF CHROMIUM HYDROXIDE.

CHEMICAL REDUCTION FOLLOWED BY PRECIPITATION REQUIRES SEVERAL PROCESS STEPS, CONSUMES CHEMICAL ADDITIVES FOR PH ADJUSTMENT AND THE REDUCTION REACTION, AND GENERATES A SLUDGE THAT MUST BE DISPOSED OF AN AUTOMATED SYSTEM COULD BE PROVIDED TO CARRY OUT THESE OPERATIONS; HOWEVER, SOME OPERATOR ATTENTION WOULD BE REQUIRED. CHEMICAL REDUCTION CAN BE CARRIED OUT USING SIMPLE, READILY AVAILABLE EQUIPMENT AND REAGENTS.

CHEMICAL REDUCTION IS USED PRIMARILY FOR THE REDUCTION OF HEXAVALENT CHROMIUM, MERCURY, AND LEAD AND IS A WELL TESTED AND DOCUMENTED METHOD OF TREATMENT FOR THESE METALS. DUE TO ITS DOCUMENTED APPLICABILITY, LABORATORY AND PILOT-SCALE TESTS MAY NOT BE REQUIRED TO DETERMINE APPROPRIATE CHEMICAL FEED RATES AND REACTOR RETENTION TIME FOR THE REDUCTION OF HEXAVALENT CHROMIUM TO TRIVALENT CHROMIUM AT THE CWP SITE.

THE TOTAL CAPITAL COSTS FOR CHEMICAL REDUCTION, INCLUDING THE COSTS FOR CHEMICAL STORAGE, FEEDING, AND MIXING, WERE ESTIMATED TO BE $224,000 WITH A TOTAL ANNUAL O&M COST OF 5192,300 (US EPA, 1978) THESE COST ESTIMATES ARE BASED ON A 20 GPM SYSTEM USING THE 1987 ENR CONSTRUCTION COST INDEX.

7.1.3.3 CHEMICAL PRECIPITATION WITH SEDIMENTATION OR FILTRATION

THIS TECHNOLOGY INVOLVES THE ADDITION OF CHEMICALS TO AN AQUEOUS SOLUTION TO COMBINE DISPERSED PARTICLES INTO LARGER AGGLOMERATES WHICH ARE REMOVED DURING THE PRECIPITATION (SETTLING) PROCESS. PRECIPITATION IS A PHYSICOCHEMICAL PROCESS WHEREBY SOME OR ALL OF A SUBSTANCE IN SOLUTION IS TRANSFORMED INTO A SOLID PHASE. GENERALLY, LIME OR SODIUM SULFIDE IS ADDED TO THE GROUND WATER IN A RAPID MIXING TANK. THE WATER FLOWS TO A FLOCCULATION CHAMBER IN WHICH ADEQUATE MIXING AND RETENTION TIME IS PROVIDED FOR AGGLOMERATION OF PRECIPITATION PARTICLES BY ADDING AN AGENT SUCH AS ALUM. AGGLOMERATED PARTICLES ARE SEPARATED FROM THE LIQUID PHASE BY SETTLING IN A SEDIMENTATION CHAMBER AND/OR BY OTHER PHYSICAL PROCESSES SUCH AS FILTRATION.

PRECIPITATION IS APPLICABLE TO THE REMOVAL OF MOST METALS FROM WASTEWATER INCLUDING ZINC, CADMIUM, CHROMIUM, COPPER, FLUORIDE, LEAD, MANGANESE, AND MERCURY. CYANIDE AND OTHER IONS IN THE WASTEWATER MAY ALSO COMPLEX WITH METALS, MAKING TREATMENT BY PRECIPITATION LESS EFFICIENT. PRECIPITATION IS NON-SELECTIVE IN THAT COMPOUNDS OTHER THAN THOSE TARGETED MAY BE REMOVED. BOTH PRECIPITATION AND FLOCCULATION ARE NONDESTRUCTIVE AND GENERATE A LARGE VOLUME OF SLUDGE WHICH MUST BE DISPOSED. THE TECHNOLOGY IS, HOWEVER, CONSIDERED TO BE POTENTIALLY APPLICABLE TO THE TREATMENT OF CHROMIUM-CONTAINING GROUND WATER AT THE SITE.

PRECIPITATION AND FLOCCULATION POSE MINIMAL HEALTH AND SAFETY HAZARDS TO FIELD WORKERS. THE ENTIRE SYSTEM IS OPERATED AT NEAR AMBIENT CONDITIONS, ELIMINATING THE DANGER OF HIGH PRESSURE/HIGH TEMPERATURE OPERATION. WHILE THE CHEMICALS EMPLOYED ARE OFTEN SKIN IRRITANTS, THEY CAN BE HANDLED IN A SAFE MANNER.

ARUMU GAM (1976) STUDIED HYDROXIDE PRECIPITATION FOR THE RECOVERY OF CHROMIUM FROM SPENT TAN LIQUOR. THIS PRECIPITATION PROCESS WAS THE LEAST EXPENSIVE METHOD FOR THE REMOVAL AND RECOVERY OF CHROMIUM. USING LIME AND AT AN OPTIMUM PH OF 6.6, THE REMOVAL OF CHROMIUM EXCEEDED 98 PERCENT. THE PRECIPITATED CHROMIUM HYDROXIDE IS SEPARATED BY SETTLING, FILTERED, AND REDISSOLVED IN SULFURIC ACID TO FORM CHROMIUM SULFATE WHICH CAN BE RECYCLED FOR FURTHER TANNING. THE USE OF LIME WAS MORE ECONOMICAL THAN THE USE OF OTHER ALKALINES (NAOH, NA2CO3, AND NH4OH). THE USE OF LIME SOFTENING AND COAGULATION, USING ALUM FOR REMOVAL OF SUCH HEAVY METALS AS CR(III) AND CR(VI), HAS BEEN INVESTIGATED BY THE EPA (US EPA, 1978).

FOR A 20 GPM CHROMIUM REMOVAL SYSTEM, THE EQUIPMENT COST IS ESTIMATED TO BE $50,000 (EPA/625/6-85/006, UPDATED TO 1987 USING THE ENR CONSTRUCTION COST INDEX). A TOTAL CHEMICAL

COST OF $4.80 PER 1,000 GALLONS IS ESTIMATED FOR THIS PRECIPITATION PROCESS TO ACHIEVE AN EFFLUENT CONTAINING LESS THAN 0.05 MG/L OF CHROMIUM. THE ANNUAL O&M COST IS ESTIMATED TO BE $64,000 WITH A TOTAL CAPITAL COST OF $192,000.

7.1.3.4 ACTIVATED CARBON ADSORPTION

CHROMATES CAN BE EFFECTIVELY REMOVED FROM GROUND WATER BY PASSING THE CHROMATE-CONTAINING GROUND WATER THROUGH A COLUMN PACKED WITH ACTIVATED CARBON (YOSHIDA, ET AL., 1977). HUANG AND WU (1975) FOUND THAT THE REMOVAL OF CR(VI) BY CALCINATED CHARCOAL WAS MOST SIGNIFICANT AT LOW PH AND FOR LOW INITIAL CR(VI) CONCENTRATIONS. LANDRIGAN AND HALLOWELL (1975) DEMONSTRATED THAT ACTIVATED CARBON COULD BE USED BY SMALL PLATING FACILITIES FOR REMOVAL OF CHROMIUM. HUANG AND WU (1975) STUDIED THE EFFECT OF PH ON CR(III) AND CR(VI)

ADSORPTION BY FILTRASORB 400 ACTIVATED CARBON. CR(VI) WAS AT LEAST TWICE AS ADSORBABLE AS CR(III). THE OPTIMUM PH FOR ADSORPTIVE REMOVAL WAS 5.5 TO 6.0 FOR CR(VI) AND 5.0 FOR CR(III).

GRANULAR ACTIVATED CARBON (GAC) IS USUALLY PREFERRED SINCE IT CAN BE CHEMICALLY REGENERATED AND REUSED. POWDERED ACTIVATED CARBON (PAC) IS LESS EXPENSIVE, BUT IT CAN ONLY BE USED ON A ONCE-THROUGH BASIS.

ACTIVATED CARBON WILL ADSORB HEXAVALENT CHROMIUM AND MANY METALS COMPLEXED IN ORGANIC FORM. THE ADSORPTIVE CAPACITY DEPENDS ON THE CARBON PORE SIZE, SOLUTION PH, AND THE INITIAL AND FINAL CONCENTRATIONS OF THE METAL(S). ACTIVATED CARBON ADSORPTION IS CONSIDERED TO BE AN APPLICABLE TECHNOLOGY FOR THE REMOVAL OF CR(VI) FROM GROUND WATER AT THE CWP SITE. IN PARTICULAR, ACTIVATED CARBON ADSORPTION SHOWS CONSIDERABLE PROMISE FOR REMOVING LOW CONCENTRATIONS OF CHROMIUM (IN THE RANGE OF 1 TO 2 ,MG/L) REMAINING AFTER OTHER TREATMENT METHODS SUCH AS PRECIPITATION, CEMENTATION, ETC. REGENERATION OF THE SPENT CARBON IS POSSIBLE WITH THE USE OF CAUSTIC SOLUTION.

THERE ARE A NUMBER OF OPERATIONAL CONSIDERATIONS, HOWEVER, THAT MAKE CARBON ADSORPTION AN INAPPROPRIATE CHOICE AS A TREATMENT OPTION FOR GROUND WATER CONTAINING CR(VI), AS DISCUSSED BELOW:

- ON THE CARBON SURFACE, CR(VI) IS PARTIALLY REDUCED TO CR(III) WHICH DOES NOT ADSORB WELL ON CARBON.
- THE MAXIMUM ADSORPTION OF CR(VI) OCCURS AT A PH OF APPROXIMATELY 2.5. AT LOWER PH VALUES, THE CR(VI) IS REDUCED TO CR(III); AT HIGHER PH VALUES, THE ADSORPTION OF CR(VI) DECREASES RAPIDLY.
- CR(VI) CAN BE STRIPPED FROM THE CARBON WITH A CAUSTIC SOLUTION. REMOVAL OF CR(VI) CAN THEN BE ACCOMPLISHED BY CHEMICAL ADDITION AND PH ADJUSTMENT IN A MIXING VESSEL; HOWEVER, A CHROMIUM-CONTAMINATED SLUDGE IS GENERATED.

A CARBON ADSORPTION SYSTEM WITH CAUSTIC REGENERATION COULD BE DESIGNED TO REMOVE CR(VI) FROM GROUND WATER AT THE SITE, BUT CR(III) WOULD NOT BE REMOVED BY THIS METHOD. ALTHOUGH IT IS TRUE THAT HIGHER CONCENTRATIONS OF CR(III) IN THE EFFLUENT CAN BE TOLERATED, FOR CERTAIN METHODS OF TREATED WATER DISCHARGE, LOWER CONCENTRATIONS OF CR(III) ARE ADVANTAGEOUS. CERTAIN EQUIPMENT AND CHEMICALS ARE NEEDED TO CARRY OUT PH ADJUSTMENT OF THE GROUND WATER AND IN THE ADSORPTION OPERATION.

TYPICAL CAPITAL AND O&M COSTS ARE PRESENTED IN TABLE 13. ADDITIONAL EQUIPMENT, CONTROLS, AND CHEMICALS WOULD BE REQUIRED FOR CARBON REGENERATION, WHICH IS PREFERRED OVER A NONREGENERATION APPROACH, TO MINIMIZE THE COST OF CARBON REPLACEMENT CONTAMINATED CARBON DISPOSAL. HOWEVER, EVEN WITH THE USE OF CARBON REGENERATION, DISPOSAL OF CHROMIUM CONTAMINATED SLUDGE AND SOME SPENT CARBON WOULD BE NECESSARY. FOR THE REASONS STATED ABOVE, CARBON ADSORPTION WOULD NOT BE A COST-EFFECTIVE OPTION FOR THE REMOVAL OF CHROMIUM FROM GROUND WATER AT THE SITE.

7.1.3.5 ION EXCHANGE

THE ION EXCHANGE PROCESS FOR CHROMIUM REMOVAL IS SIMILAR IN OPERATION TO THE CARBON ADSORPTION SYSTEM DISCUSSED IN SECTION 7.1.3.4, WASTEWATER IS PASSED THROUGH A BED OF ION EXCHANGE RESIN, WHICH CONTAINS ACTIVE IONIC FUNCTIONAL GROUPS. CHROMIUM IONS ARE EXCHANGED AND REMOVED FROM THE

RESIN AND THEN SEPARATED BY PH ADJUSTMENT AND PRECIPITATION. ION EXCHANGE IS A PROCESS WHEREBY THE MOBILE IONS ARE REMOVED FROM THE GROUND WATER PHASE BY BEING EXCHANGED WITH RELATIVELY IMMOBILE IONS HELD BY THE ION EXCHANGE MATRIX (WEBER, 1972). THE REMOVAL OF CHROMIUM DEPENDS PRIMARILY ON THE VALENCE OF THE CHROMIUM ION, THE TYPE OF RESIN, AND THE CHROMIUM CONCENTRATION IN GROUND WATER. THE CHROMATE-DICHROMATE PAIR OF DIVALENT ANIONS PRESENTS A DIFFERENT CASE. IN ALKALINE SOLUTIONS, HEXAVALENT CHROMIUM EXISTS IN SOLUTION AS THE CHROMATE ION CRO4. AS PH DROPS BELOW 6, CHROMATE IONS CONDENSE TO FORM DICHROMATE IONS CR2O72 BOTH IONS APPEAR TO BE HELD SELECTIVELY OVER COMMON MONOVALENT ANIONS.

(R4N)2, CR2O72 + 2NAOH ----
(R4N)2, (CRO)4 + NA2CRO4+H2O

THIS REVERSIBILITY IS USED IN REMOVING HEXAVALENT CHROMIUM FROM GROUND WATER.

GROUND WATER ENTERS THE TOP OF THE RESIN COLUMN UNDER PRESSURE, PASSES DOWNWARD THROUGH THE RESIN BED, AND IS REMOVED AT THE BOTTOM. WHEN THE RESIN CAPACITY IS EXHAUSTED, THE COLUMN IS BACKWASHED TO REMOVE TRAPPED SOLIDS AND THEN REGENERATED. SUSPENDED SOLIDS IN THE FEED STREAM SHOULD BE LESS THAN 50 MG/L TO PREVENT PLUGGING THE RESINS. THE CATIONIC EXCHANGE RESIN IS REGENERATED WITH A STRONG ACID, SUCH AS SULFURIC ACID OR HYDROCHLORIC ACID. SODIUM HYDROXIDE IS A COMMONLY USED REGENERANT FOR ANION EXCHANGE RESIN. THIS PROCESS CAN TAKE PLACE IN SEPARATE EXCHANGE COLUMNS ARRANGED IN SERIES, OR BOTH RESINS CAN BE MIXED IN A SINGLE REACTOR (ELZEL AND TSENG, 1984).

FOR THE REDUCTION OF CR(VI) AND CR(III), BOTH ANIONIC AND CATIONIC EXCHANGE RESINS MUST BE USED. THE GROUND WATER IS FIRST PASSED THROUGH A CATION EXCHANGER WHERE THE POSITIVELY CHARGED IONS, SUCH AS CR (VI), ARE REPLACED BY HYDROGEN IONS. THE CATION EXCHANGER EFFLUENT IS THEN PASSED OVER AN ANIONIC EXCHANGE RESIN WHERE THE ANIONS ARE REPLACED BY HYDROXIDE IONS. THUS, THE CHROMIUM IONS ARE REPLACED BY HYDROGEN AND HYDROXIDE IONS THAT REACT TO FORM WATER MOLECULES.

HEXAVALENT CHROMIUM CAN BE SUCCESSFULLY RECOVERED USING ION EXCHANGE TREATMENT. BECAUSE OF FACTORS SUCH AS RESIN CAPACITY AND THE NUMBER OF TIMES THE RESIN CAN BE REGENERATED, THIS TECHNOLOGY IS USUALLY APPLICABLE ONLY TO THOSE SITUATIONS INVOLVING RELATIVELY LOW INFLUENT CONCENTRATIONS. REMOVAL EFFICIENCIES OF 90 TO 99 PERCENT HAVE BEEN REPORTED FOR THE TREATMENT OF GROUND WATER WITH A CONVENTIONAL TWO-STAGE EXCHANGER SYSTEM. EVEN HIGHER REMOVALS ARE POSSIBLE WITH MIXED-BED EXCHANGERS.

THE UNIT VOLUME COST FOR STRONG-BASE RESINS IS 3 TO 4 TIMES THAT OF STRONG-ACID RESINS. THE HIGHER COST OF STRONG-BASE RESINS IS DUE TO THE CONSIDERABLY MORE COMPLEX MANUFACTURING PROCESS REQUIRED FOR THE ANION RESINS.

THE ADVANTAGES OF THE ION EXCHANGE PROCESS ARE:

- SIMPLE, BASIC TYPE OF UNIT WITH EASY MAINTENANCE.
- BETTER QUALITY CONTROL DUE TO ELIMINATION OF PROCESS VARIABILITY.
- REDUCED WASTE DISPOSAL COSTS.

ION EXCHANGE HAS SIMILAR DISADVANTAGES TO CARBON ADSORPTION FOR APPLICATION TO THE TREATMENT OF GROUND WATER FROM THE SITE. SPECIFICALLY, THE ION EXCHANGE, REGENERATION, AND CHROMIUM PRECIPITATION OPERATIONS REQUIRE A VARIETY OF EQUIPMENT, CONTROLS, CHEMICALS, AND LABOR. THESE ITEMS RESULT IN HIGH CAPITAL AND OPERATIONAL COSTS. INCLUDED IN THESE EXPENSES IS THE HIGH COST OF ION EXCHANGE RESIN. IF BOTH CR(VI) AND CR(III) ARE PRESENT IN THE WASTEWATER, TWO RESIN BEDS WOULD BE REQUIRED BECAUSE CR(VI) ABSORBS ON ANION RESIN (CR+6 EXISTING AS CRO4-2) AND CR(III) ABSORBS ON CATION RESIN. REGENERATION AND PRECIPITATION OF CHROMIUM WOULD ALSO BE FURTHER COMPLICATED IF BOTH CR(III) AND CR(VI) ARE PRESENT IN THE GROUND WATER. THE MAJOR DISADVANTAGES OF THIS TECHNOLOGY ARE AS FOLLOWS:

- HIGH REGENERATION COST.
- FLUCTUATING EFFLUENT QUALITY.
- REQUIRES SUBSTANTIAL FLOOR SPACE.

THE CONSTRUCTION COST FOR A SYSTEM CAPABLE OF HANDLING 20 GPM, INCLUDING A STEEL CONTACT VESSEL,

A RESIN DEPTH OF 6 FEET, HOUSING FOR THE COLUMNS, AND ALL PIPING AND BACKWASH FACILITIES, IS ESTIMATED TO BE $84,000 WITH AN O&M COST OF $14,000. THE O&M COST INCLUDES ELECTRICITY FOR BACKWASHING AND PERIODIC REPAIR AND REPLACEMENT COSTS. COSTS FOR REGENERANT CHEMICALS ARE NOT INCLUDED BECAUSE THEY VARY DEPENDING ON THE CONCENTRATIONS OF CHROMIUM TO BE REMOVED FROM THE GROUND WATER.

7.1.3.6 REVERSE OSMOSIS

IF A PRESSURE EQUAL TO OR GREATER THAN THE OSMOTIC PRESSURE IS APPLIED TO THE SOLUTION SIDE OF A MEMBRANE, THE SOLVENT WILL FLOW ACROSS THE MEMBRANE LEAVING A MORE CONCENTRATED SOLUTION. THIS PROCESS IS KNOWN AS REVERSE OSMOSIS. SUFFICIENTLY HIGH PRESSURE, USUALLY IN THE RANGE OF 200 TO 400 PSI, WILL FORCE THE SOLVENT OUT OF SOLUTION, PRODUCING A MORE CONCENTRATED STREAM WHICH MUST BE TREATED FURTHER OR DISPOSED OF. IONS AND SMALL MOLECULES IN GROUND WATER CAN BE SEPARATED FROM WATER BY THIS TECHNIQUE. THE CONCENTRATED WASTE STREAM REQUIRES ADDITIONAL TREATMENT TO REMOVE OR RECOVER THE CHROMIUM.

THE BASIC COMPONENTS OF A REVERSE OSMOSIS UNIT ARE THE MEMBRANE, A MEMBRANE SUPPORT STRUCTURE, A CONTAINING VESSEL, AND A HIGH PRESSURE PUMP. THE MEMBRANE AND MEMBRANE SUPPORT STRUCTURE ARE THE MOST CRITICAL ELEMENTS. THE FACT THAT REVERSE OSMOSIS UNITS CAN BE OPERATED IN SERIES OR IN PARALLEL PROVIDES SOME FLEXIBILITY IN DEALING WITH INCREASED FLOW RATES OR CONCENTRATIONS OF DISSOLVED SPECIES.

AVAILABLE INFORMATION AND EXPERIENCE IS LIMITED REGARDING THE USE OF REVERSE OSMOSIS FOR GROUND WATER TREATMENT. A HEXAVALENT CHROMIUM REMOVAL EFFICIENCY OF 93.5 PERCENT HAS BEEN REPORTED FOR AN INFLUENT CONCENTRATION OF 49.6 MG/L (HINDIN, 1968). THE VOLUME OF THE REJECT GENERATED BY REVERSE OSMOSIS IS ABOUT 10 TO 25 PERCENT OF THE FEED VOLUME. PROVISIONS MUST BE MADE TO TREAT THIS POTENTIALLY HAZARDOUS WASTE. PRETREATMENT OF THE SECONDARY EFFLUENT WITH FILTRATION AND CARBON ADSORPTION IS USUALLY NECESSARY.

A VERY HIGH QUALITY FEED IS REQUIRED FOR EFFICIENT OPERATION OF A REVERSE OSMOSIS UNIT. THE REMOVAL OF IRON AND MANGANESE IS ALSO NECESSARY TO DECREASE SCALING POTENTIAL. THE PH OF THE FEED SHOULD BE ADJUSTED TO A RANGE OF 4.0 TO 7.5 TO INHIBIT SCALE FORMATION. THE PRIMARY LIMITATIONS OF REVERSE OSMOSIS ARE ITS HIGH COST AND THE PROBLEM OF A CONCENTRATED WASTE STREAM WHICH MUST BE TREATED FURTHER USING ANOTHER TECHNOLOGY. BECAUSE OF THE LOW REMOVAL EFFICIENCY AND HIGH QUALITY FEED REQUIREMENTS, REVERSE OSMOSIS IS NOT CONSIDERED TO BE APPLICABLE TO THE TREATMENT OF GROUND WATER AT THE CWP SITE.

THE TOTAL CAPITAL COST, INCLUDING HOUSING, TANKS, PIPING, MEMBRANES, FLOW METERS, CARTRIDGE FILTERS, ACID AND POLYPHOSPHATE FEED EQUIPMENT, AND CLEANUP EQUIPMENT, TO TREAT 20 GPM ARE ESTIMATED TO BE $400,000 WITH A TOTAL ANNUAL O&M COST OF $150,000. THE O&M COSTS INCLUDE ELECTRICITY FOR THE HIGH PRESSURE FEED PUMPS (450 PSI OPERATING PRESSURE), BUILDING UTILITIES, ROUTINE PERIODIC REPAIR, ROUTINE CLEANING, AND MEMBRANE REPLACEMENT EVERY THREE YEARS (EPA 600-8-80-042D).

7.1.3.7 ELECTRODIALYSIS

IN THE ELECTRODIALYSIS PROCESS, IONIC COMPONENTS OF A SOLUTION, SUCH AS CR (VI), ARE SEPARATED THROUGH THE USE OF SEMI-PERMEABLE ION-SELECTIVE MEMBRANES. APPLICATION OF AN ELECTRICAL POTENTIAL BETWEEN THE TWO ELECTRODES CAUSES ELECTRIC CURRENT TO PASS THROUGH THE SOLUTION, WHICH, IN TURN, CAUSES A MIGRATION OF CATIONS TOWARD THE NEGATIVE ELECTRODE AND A MIGRATION OF ANIONS TOWARD THE POSITIVE ELECTRODE. BECAUSE OF THE ALTERNATE SPACING OF CATION AND ANION PERMEABLE MEMBRANES, CELLS OF CONCENTRATED AND DILUTE SOLUTION ARE FORMED (POON AND LU, 1981).

GROUND WATER IS PUMPED THROUGH THE MEMBRANES WHICH ARE SEPARATED BY SPACERS AND ASSEMBLED INTO STAGES. THE RETENTION TIME IN EACH STAGE IS USUALLY ABOUT 10 TO 20 SECONDS. REMOVAL OF CHROMIUM FROM GROUND WATER VARIES WITH:

- GROUND WATER TEMPERATURE
- AMOUNTS OF ELECTRICAL CURRENT PASSED
- AMOUNT OF CR(VI) AND/OR CR(III) IONS
- FOULING AND SCALING POTENTIAL
- NUMBER AND CONFIGURATION OF STAGES.

THIS PROCESS MAY BE OPERATED IN EITHER A CONTINUOUS OR A BATCH MODE. THE UNITS CAN BE ARRANGED EITHER IN PARALLEL TO PROVIDE THE NECESSARY HYDRAULIC CAPACITY OR IN SERIES TO ACHIEVE THE DESIRED DEGREE OF CHROMIUM REMOVAL. MAKEUP WATER, USUALLY ABOUT 10 PERCENT OF THE FEED VOLUME, IS REQUIRED TO WASH THE MEMBRANES CONTINUOUSLY. A PORTION OF THE CONCENTRATE STREAM IS RECYCLED TO MAINTAIN NEARLY EQUAL FLOW RATES AND PRESSURES ON BOTH SIDES OF EACH MEMBRANE. SULFURIC ACID IS FED TO THE CONCENTRATE STREAM TO MAINTAIN A LOW PH AND, THUS, MINIMIZE SCALING.

TO ACHIEVE HIGH THROUGHPUT, ELECTRODIALYSIS CELLS IN PRACTICE ARE MADE VERY THIN AND ASSEMBLED IN STACKS OF CELLS IN SERIES. EACH STACK OF 10 CONSISTS OF MORE THAN 100 CELLS. GENERALLY, ELECTRODIALYSIS WORKS BEST ON ACIDIC STREAMS CONTAINING A SINGLE PRINCIPAL METAL ION.

AN ELECTRODIALYSIS PLANT PRODUCES TWO PRODUCT STREAMS, ONE DILUTE AND ONE CONCENTRATED, WHICH MAY NEED TO BE DISPOSED OR FURTHER TREATED. BECAUSE OF HYDROGEN GENERATION, THIS TECHNOLOGY MAY CAUSE SOME FOCAL AIR POLLUTION (EPA 600-8-80-042C).

ELECTRODIALYSIS HAS THE ADVANTAGE OF BEING A CONTINUOUS PROCESS WHICH, UNLIKE THE ADSORPTION PROCESS, DOES NOT REQUIRE REGENERATION. HOWEVER, ELECTRODIALYSIS IS USUALLY NOT ECONOMICAL FOR TREATMENT OF VERY DILUTE CHROMIUM SOLUTIONS LIKE THE CWP GROUND WATER AND FOR SITUATIONS WHERE LOW EFFLUENT CONCENTRATIONS ARE REQUIRED. A MORE COMMON APPLICATION FOR THIS TECHNOLOGY IS THE RECOVERY OF IONIZED SPECIES SUCH AS METAL SALTS, CYANIDES, OR CHROMATES FROM METAL FINISHING WASTEWATERS, WHICH ARE AT CONSIDERABLY HIGHER CONCENTRATIONS THAN THE GROUND WATER.

PROBLEMS ASSOCIATED WITH THE ELECTRODIALYSIS PROCESS INCLUDE CHEMICAL PRECIPITATION ON THE MEMBRANE SURFACE AND CLOGGING OF THE MEMBRANE BY THE RESIDUAL COLLOIDAL ORGANIC MATTER IN GROUND WATER. TO REDUCE MEMBRANE FOULING, ACTIVATED CARBON PRETREATMENT, POSSIBLY PRECEDED BY CHEMICAL PRECIPITATION AND SOME FORM OF MULTIMEDIA FILTRATION, MAY BE REQUIRED. THIS PROCESS MAY, THEREFORE, REQUIRE MORE ATTENTION AND MAINTENANCE THAN OTHER SYSTEMS DISCUSSED IN PREVIOUS SECTIONS. ALSO, THIS PROCESS IS NOT AN ESTABLISHED TECHNOLOGY FOR THE SUBJECT APPLICATION. IT IS STILL CONSIDERED TO BE POSSIBLY APPLICABLE TO THE TREATMENT OF GROUND WATER AT THE CWP SITE.

THE CAPITAL COST ASSOCIATED WITH THIS OPTION IS APPROXIMATELY $85,000. THE O&M COSTS ARE ESTIMATED AT $1.00 PER 1,000 GALLONS.

7.1.4 ALTERNATIVES FOR DISCHARGE OF EXTRACTED WATER

GROUND WATER EXTRACTION FOR PLUME CONTROL AND REMEDIATION REQUIRES AN APPROPRIATE MEANS OF HANDLING THE PUMPED WATER. THE OPTIONS CONSIDERED FOR HANDLING EXTRACTED GROUND WATER, EITHER WITH OR WITHOUT TREATMENT, ARE AS FOLLOWS:

- RECYCLING
- SANITARY SEWER DISCHARGE
- SURFACE WATER DISCHARGE
- SUBSURFACE INJECTION.

7.1.4.1 RECYCLING

THE MOST COST-EFFECTIVE METHOD OF HANDLING THE CONTAMINATED WATER IS TO RECYCLE THE PUMPED WATER INTO CWP OPERATIONS WITHOUT TREATMENT. THIS WOULD BE POSSIBLE SO LONG AS CWP'S DEMAND WAS LARGER THAN THE VOLUME EXTRACTED. OTHERWISE, PARTIAL RECYCLING COMBINED WITH TREATMENT/DISPOSAL OF THE BALANCE COULD BE PERFORMED.

TO EXPLORE THE POSSIBILITY OF RECYCLING, A REVIEW OF THE WATER BALANCE IS NECESSARY. THE TOTAL SURFACE WATER COLLECTION AREA IS 22,840 FT2. THUS, ONE INCH OF RAIN GENERATES 14,180 GALLONS OF RUNOFF. THE STORM EVENTS OF INTEREST AND THE CORRESPONDING VOLUME OF WATER ARE AS FOLLOWS (DEPARTMENT OF WATER RESOURCES, 1976):

STORM EVENT	RAINFALL (INCHES)	WATER (GALLONS)
10-YEAR WINTER	48.93	693,827
100-YEAR/24-HOUR	6.66	94,439

THE CWP OPERATION USES 20 ABOVE-GROUND TANKS WITH A TOTAL STORAGE CAPACITY OF 752,000 GALLONS. ASSUMING THE OCCURRENCE OF A 10-YEAR WINTER STORM, THE AVAILABLE STORAGE WILL AMOUNT TO 59,173 GALLONS (752,000 MINUS 693,827). THE DAILY OPERATIONAL USE IS ABOUT 8,000 GALLONS OR APPROXIMATELY 5.5 GPM. THEREFORE, IF THE EXTRACTION SYSTEM OPERATES AT ABOUT 5 GPM DURING DRY CONDITIONS, ALL THE EXTRACTED WATER CAN BE RECYCLED. ALSO, DURING THE STORM EVENTS (10-YEAR WINTER), EXTRACTION RATES OF 4 TO 6 GPM COULD BE ACCOMMODATED FOR ABOUT EIGHT DAYS UTILIZING THE AVAILABLE STORAGE.

IT IS EVIDENT FROM THE MASS BALANCE CALCULATIONS THAT FOR EXTRACTION RATES GREATER THAN 5 GPM OR DURING THE WET WINTER MONTHS, AN ADDITIONAL DISCHARGE OPTION IS REQUIRED. IT IS IMPORTANT TO NOTE THAT HIGHER EXTRACTION RATES ARE DESIRED DURING THE WET SEASON TO ACHIEVE A GREATER DEGREE OF MIGRATION CONTROL AND REMEDIATION.

7.1.4.2 DISCHARGE INTO THE SANITARY SEWER

DISCHARGE OF TREATED GROUND WATER INTO THE SANITARY SEWER IS A VIABLE OPTION WHICH IS CURRENTLY BEING PURSUED BY CWP. THIS OPTION HAS BEEN UNDER CONSIDERATION SINCE 1983, WHEN THE CITY OF UKIAH (THE CITY) INFORMED CWP OF THE REGULATIONS CONCERNING THE CRITERIA FOR DISCHARGING WASTEWATERS INTO THE SANITARY SEWER SYSTEM. UPON THE CITY'S REQUEST, KENNEDY/JENKS ENGINEERS WERE DIRECTED TO EVALUATE THE COMPATIBILITY OF TREATED WATER FROM THE CWP FACILITY WITH THE CITY'S WASTEWATER TREATMENT PLANT REGULATIONS. THE KENNEDY/JENKS ENGINEERS (MARCH 19, 1984) EVALUATION CONCLUDED THAT A DISCHARGE OF 40,000 GALLONS PER DAY OF WASTEWATER CONTAINING NO MORE THAN 0.5 MG/L OF HEXAVALENT CHROMIUM WOULD BE ACCEPTABLE UNDER THE LIMITATIONS OF RESTRICTED DISCHARGES. THE ACCEPTABILITY OF THE WASTEWATER DISCHARGE WOULD BE SUBJECT TO VERIFICATION OF THE EXISTING BASELINE (PRE-DISCHARGE) LEVELS OF CHROMIUM PRESENT IN THE CITY SEWAGE AND SLUDGE. THE BASELINE DATA WERE SUBSEQUENTLY GENERATED AND SUBMITTED TO THE CITY. ON APRIL 30, 1987, CWP SUBMITTED A PROPOSAL TO DISCHARGE THE ELECTROCHEMICALLY-TREATED WATER DURING THOSE PERIODS WHEN EXTRACTED GROUND WATER CANNOT BE RECYCLED OR STORED ON SITE (CWP, APRIL 30, 1987). THIS PROPOSAL PROVIDED THE REQUIRED BASELINE DATA AND THE ELECTROCHEMICAL TREATMENT UNIT INFLUENT AND EFFLUENT CHROMIUM CONCENTRATIONS. THE DATA PROVIDED DEMONSTRATED THAT THE EXISTING DISCHARGE LIMITATIONS CAN BE COMPLIED WITH. THE MAXIMUM CHROMIUM CONCENTRATION IN THE ELECTROCHEMICAL TREATMENT SYSTEM EFFLUENT WAS SPECIFIED AS 0.1 MG/L. THE CITY HAS PROVIDED CWP WITH AN AUTHORIZATION TO DISCHARGE SUBJECT TO CERTAIN PROVISIONS, PROHIBITIONS, AND REQUIREMENTS AS OUTLINED IN TABLE 15. CWP IS CURRENTLY REVIEWING THE CITY'S REQUIREMENTS.

7.1.4.3 DISCHARGE INTO THE SURFACE DRAINAGE SYSTEM

ANOTHER POSSIBLE METHOD OF HANDLING EXCESS TREATED WATER IS DISCHARGE TO THE SURFACE DRAINAGE DITCH TO THE EAST OF THE SITE. AS DISCUSSED IN SECTION 4.3, THIS DRAINAGE DITCH EVENTUALLY REPORTS TO THE RUSSIAN RIVER, ALTHOUGH SOME SEEPAGE INTO THE VALLEY FILL DEPOSITS IS LIKELY TO OCCUR. THE DITCH HAS THE CAPACITY TO ACCEPT EXCESS DISCHARGED WATER, EVEN DURING PEAK FLOW PERIODS. IMPLEMENTATION OF THIS OPTION WOULD ONLY BE POSSIBLE IF RESTRICTIONS ON DISCHARGE INTO THE RUSSIAN RIVER AND ITS TRIBUTARIES ARE RELAXED. THE PROBABLE DEVELOPMENT OF MORE STRINGENT DISCHARGE RESTRICTIONS DOES NOT MAKE THIS OPTION A PROMISING OR FEASIBLE ALTERNATIVE AT THIS TIME.

7.1.4.4 SUBSURFACE INJECTION

INJECTION OF EXCESS TREATED WATER INTO THE MORE PERMEABLE STRATA BENEATH THE SITE IS MORE APPROPRIATE DURING THE DRY SEASONS WHEN GROUND WATER LEVELS ARE GENERALLY LOWER. CWP HAS ATTEMPTED TO IMPLEMENT THIS OPTION BY INSTALLING INJECTION WELL CWP-19 UPGRADIENT OF THE CONTAMINATED ZONE. DURING THE WET WINTER MONTHS, HOWEVER, WHEN THE VOLUME OF WATER TO BE DISPOSED IS GREATEST, WELL CWP-19 HAS NOT BEEN ABLE TO ACCOMMODATE THE REQUIRED FLOW. DURING THE DRIER MONTHS WHEN GROUND WATER IS DEEPER, THIS DISCHARGE ALTERNATIVE MAY BE NECESSARY IN ORDER TO FLUSH THE CONTAMINANTS TOWARD THE EXTRACTION WELL. ONE OF THE MAJOR DISADVANTAGES OF THIS METHOD IS BIO-FOULING AND MICROBIAL GROWTH IN THE INJECTION WELLS, REQUIRING FREQUENT MAINTENANCE.

7.2 RECOMMENDED REMEDIAL ACTION

THIS SECTION DESCRIBES THE RECOMMENDED REMEDIAL ACTION BASED ON THE SCREENING OF VARIOUS ALTERNATIVES PRESENTED IN SECTION 7.3. THE RATIONALE FOR SELECTION OF THE RECOMMENDED ALTERNATIVE AND REJECTION OF THE OTHERS, AND A DESCRIPTION OF THE ENVIRONMENTAL EFFECTS OF THE

RECOMMENDED ALTERNATIVE ARE ALSO PROVIDED. THE COMPONENTS OF THE RECOMMENDED REMEDIAL ACTION PLAN ARE AS FOLLOWS:

- SURFACE RUNOFF MANAGEMENT
- CONTROL OF CONTAMINATED SOIL
- PLUME CONTROL AND AQUIFER REMEDIATION
- ELECTROCHEMICAL TREATMENT OF GROUND WATER
- WATER RECYCLING/DISCHARGE TO THE UKIAH SEWAGE TREATMENT PLANT OR REINJECTION
- MONITORING.

EACH OF THE ABOVE COMPONENTS IS DESCRIBED BELOW.

7.2.1 SURFACE RUNOFF FLOW MANAGEMENT

SURFACE RUNOFF SHALL BE CONTROLLED IN ORDER TO PREVENT THE DISCHARGE OF POTENTIALLY CONTAMINATED WATER TO SURFACE WATERS. THE REMAINING UNPAVED PORTIONS OF THE SITE SHALL BE PAVED. THE AREA LOCATED ADJACENT TO THE 330,000-GALLON STORAGE TANK SHALL ALSO BE REGRADED AND REPAVED TO PREVENT PONDING. THE SITE SHALL BE INSPECTED PERIODICALLY, AT LEAST ONCE PER YEAR BEFORE THE WET SEASON, AND SURFACE PAVING AND DRAINAGE FEATURES REPAIRED AS APPROPRIATE. PARTICULAR ATTENTION SHALL BE GIVEN TO AREAS AROUND THE SUMPS AND RETORTS. MOBILE EQUIPMENT (E.G., FORKLIFTS) SHALL BE DESIGNATED FOR EXCLUSIVE USE IN THE RETORT AREA, TREATED WOOD STORAGE AREA, OR UNTREATED WOOD STORAGE AREA TO PREVENT CROSS SURFACE CONTAMINATION. STORM WATER MONITORING SHALL BE PERFORMED IN ACCORDANCE WITH RWQCB ORDER NO. 85-101. THE RESULTS OF STORM WATER QUALITY MONITORING WILL BE EVALUATED AND APPROPRIATE ACTIONS TAKEN ACCORDINGLY.

7.2.2 CONTROL OF CONTAMINATED SOIL

THE CONTAMINATED SOIL SHALL BE CONTROLLED BY PREVENTING SURFACE WATER INFILTRATION AND BY EXERCISING HYDRAULIC CONTROL OF THE PLUME IN ZONE 1. AS DESCRIBED IN SECTION 5.0, THESE REMEDIAL MEASURES HAVE BEEN PARTIALLY IMPLEMENTED AT THE CWP SITE. SURFACE PAVING HAS BEEN INSTALLED TO PREVENT THE PASSAGE OF WATER THROUGH THE NEAR-SURFACE, CHROMIUM-CONTAINING SOIL. CONSEQUENTLY, THE SOIL IS NOT EXPECTED TO BE A SIGNIFICANT SOURCE OF CONTAMINATION BY SURFACE WATER INFILTRATION DURING THE OPERATION OF THE FACILITY. POSTCLOSURE REMEDIAL MEASURES INCLUDE ON-SITE TREATMENT OF THE CONTAMINATED SOIL TO A DEPTH OF 1.5 FEET FOR AREAS CONTAINING GREATER THAN 100 MG/KG OF TOTAL CHROMIUM AND 15 MG/KG OF ARSENIC. BENEATH AND AROUND THE RETORT AND SUMP AREAS, THE DEPTH OF EXCAVATION IS EXPECTED TO BE 5 FEET. TREATABILITY STUDIES WILL BE CONDUCTED PRIOR TO SELECTING THE FINAL SOIL REMEDY AT THE TIME OF CLOSURE OF THE FACILITY.

CONTAMINATED SOIL THAT COMES IN CONTACT WITH GROUND WATER DURING SEASONAL HIGH GROUND WATER CONDITIONS WILL BE CONTROLLED HYDRAULICALLY. THE HYDRAULIC CONTROL MEASURES INCLUDE GROUND WATER EXTRACTION NEAR THE RETORT AREA FROM WELL CWP-18 AND NEAR THE SITE BOUNDARY FROM WELL HL-7. DETAILS OF THE HYDRAULIC CONTROL MEASURES ARE PRESENTED IN SECTION 7.2.3. THE PROPOSED APPROACH SHALL PREVENT DIRECT HUMAN EXPOSURE TO CONTAMINATED SOIL, ELIMINATE THE CONTRIBUTION OF INFILTRATING SURFACE WATER TO GROUND WATER CONTAMINATION, AND PREVENT OFF-SITE MIGRATION. IMPLEMENTATION OF THESE MEASURES, COMBINED WITH PROPER TREATED WOOD HANDLING PRACTICES, SHOULD GRADUALLY IMPROVE THE SITE CONDITIONS. THE CRITERIA FOR EVALUATING SUCH IMPROVEMENTS INCLUDE THE TREND OF CHROMIUM CONCENTRATIONS IN WELLS LOCATED NEAR THE RETORT OR PROCESS AREA. IF NO IMPROVEMENT IS OBSERVED, ADDITIONAL INVESTIGATION AND REMEDIATION ACTIONS MAY BE REQUIRED.

BASED ON THE ABOVE CONSIDERATIONS AND AGENCIES PARTICIPATION IN THE SELECTION OF REMEDIAL ALTERNATIVES, TABLE 16 SUMMARIZES THE SOIL REMEDIAL ACTION ALTERNATIVES AS SUGGESTED BY DHS. AS SHOWN IN TABLE 16, ALTERNATIVE NO. 5.2, WHICH INCLUDES ON-SITE TREATMENT OF THE CONTAMINATED SOIL, IS FAVORED BY DHS.

7.2.3 PLUME CONTROL AND AQUIFER REMEDIATION

THE ZONE OF CONTAMINATION SHALL BE CONTROLLED HYDRAULICALLY TO PREVENT OFF-SITE MIGRATION AND TO GRADUALLY REMEDIATE THE AQUIFER. THIS WILL BE ACCOMPLISHED BY EXTRACTING GROUND WATER FROM

LOCATIONS NEAR THE RETORT AREA AND NEAR THE SITE BOUNDARY. A CONTINGENCY PLAN HAS ALSO BEEN DEVELOPED FOR OFF-SITE GROUND WATER EXTRACTION, SHOULD CHROMIUM CONCENTRATIONS EXCEED A PRESCRIBED LEVEL FOR PROLONGED PERIODS OF TIME. THE "ACTION LEVEL" AND PERSISTENCE OF CHROMIUM IN OFF-SITE WELLS ARE TO BE DECIDED BY THE REGULATORY AGENCIES.

EXTRACTION FROM NEAR THE RETORT AREA WILL BE PERFORMED THROUGH WELL CWP-18, WHICH INTERCEPTS THE CHROMIUM PLUME IN ZONE 1. ALTHOUGH THIS WELL CANNOT SUSTAIN CONTINUOUS PUMPING AT HIGH FLOW RATES, THE IMPACT OF INTERMITTENT PUMPING IS STILL BELIEVED TO BE SIGNIFICANT BECAUSE OF THE HIGH CHROMIUM CONCENTRATIONS IN GROUND WATER IN THAT AREA.

EXTRACTION FROM NEAR THE SITE BOUNDARY SHALL BE PERFORMED THROUGH WELL HL-7, LOCATED TO THE WEST (HYDRAULICALLY UPGRADIENT) OF THE SLURRY WALL. AS DESCRIBED IN SECTION 5.0, WELL HL-7 IS LOCATED AT THE CENTER OF A TRENCH WHICH IS ABOUT 20 FEET DEEP AND INTERCEPTS THE CHROMIUM PLUME APPROXIMATELY PERPENDICULAR TO THE DIRECTION OF GROUND WATER FLOW. EXTRACTION FROM WELL HL-7 CAN PRODUCE A ZONE OF INFLUENCE WHICH, IN EFFECT, CONTAINS THE CHROMIUM PLUME AND PREVENTS OFF-SITE MIGRATION. THE EXTRACTION RATE FROM WELL HL-7 SHALL VARY SEASONALLY FROM 5 TO 20 GPM, DEPENDING PRIMARILY ON GROUND WATER CONDITIONS. THE EXTRACTION OF GROUND WATER FROM WELL HL-7, COMBINED WITH THE PRESENCE OF THE SLURRY WALL, IS BELIEVED TO BE THE PRINCIPAL REMEDIATION MEASURE TO PREVENT THE OFF-SITE MIGRATION OF CHROMIUM.

IN ADDITION TO CONTAINING THE CHROMIUM PLUME ON SITE, GROUND WATER EXTRACTION, PARTICULARLY FROM WELL HL-7, WILL ALSO GRADUALLY REMEDIATE THE AFFECTED WATER-BEARING ZONE. AQUIFER REMEDIATION IS ACCOMPLISHED BY REMOVING CHROMIUM-CONTAINING WATER AND REPLACING IT WITH CHROMIUM-FREE WATER. TO ESTIMATE THE TIME REQUIRED TO REMEDIATE THE WATER-BEARING ZONE, THREE FACTORS HAVE BEEN CONSIDERED, AS FOLLOWS:

- THE TOTAL FLUID PRESENT IN THE WATER-BEARING ZONE CONTAINING ELEVATED CHROMIUM CONCENTRATIONS.
- THE NUMBER OF PORE VOLUMES REQUIRED TO ACHIEVE A GIVEN CONCENTRATION LIMIT.
- THE RATE OF GROUND WATER EXTRACTION.

BASED ON THE SITE-SPECIFIC CHARACTERISTICS AND A NUMBER OF ASSUMPTIONS, THE ABOVE PARAMETERS ARE DISCUSSED BELOW.

USING THE MOST RECENT AREAL DEFINITION OF THE CHROMIUM PLUME, THE AREA CONTAINED WITHIN THE 0.02 MG/L ISOCONCENTRATION IS ESTIMATED TO BE ABOUT 130,000 FT2. BASED ON THE ASSUMPTIONS THAT THE AVERAGE SATURATED THICKNESS OF THE WATER-BEARING ZONE IS 12 FEET AND ITS EFFECTIVE POROSITY IS 0.3, THE TOTAL FLUID PRESENT IN THE WATERBEARING ZONE IS ESTIMATED TO BE ABOUT 3.5 MILLION GALLONS. APPROXIMATELY 10 PORE VOLUMES ARE ESTIMATED TO BE REQUIRED TO REDUCE THE EXISTING CHROMIUM CONCENTRATIONS TO 0.05 MG/L. THIS ESTIMATE IS BASED ON THE FOLLOWING FACTORS AND ASSUMPTIONS:

- LABORATORY ADSORPTION TEST DATA OBTAINED FROM SITE-SPECIFIC SOIL SAMPLES (IT CORPORATION, JUNE 1985).
- HIGHER DESORPTION RATE UNDER FIELD CONDITIONS AS COMPARED TO LABORATORY CONDITIONS.
- POSSIBLE REACTIONS CAUSING FIXATION AND TRANSFORMATION OF CR(VI) TO MORE INSOLUBLE FORMS WITH TIME.
- PUBLISHED AND UNPUBLISHED DATA ON CR(VI) DESORPTION.
- INACCURACIES AND UNCERTAINTIES ASSOCIATED WITH DATA TRANSLATION FROM LABORATORY TO FIELD.

THE PUMPING RATE FROM WELL HL-7 COULD VARY FROM ABOUT 5 GPM TO 20 GPM, DEPENDING ON SEASONAL HYDROLOGIC CONDITIONS, THE WATER DEMAND BY CWP'S OPERATION, AND DISCHARGE CONSTRAINTS. ASSUMING AN AVERAGE PUMPING RATE OF 10 GPM FOR THE ENTIRE DURATION OF REMEDIATION, THE TIME REQUIRED TO REMOVE ONE PORE VOLUME IS ESTIMATED TO BE ABOUT 8.5 MONTHS. THUS, BASED ON THE ABOVE ASSUMPTIONS AND CONSIDERATIONS, THE ESTIMATED TIME OF AQUIFER CLEANUP IS ABOUT SEVEN YEARS.

IN THE ABOVE CALCULATION, IT IS ASSUMED THAT THE SOIL DOES NOT ACT AS A SOURCE OF CHROMIUM TO GROUND WATER. HOWEVER, THE CHROMIUM CONTAMINATED SOIL AT THE SITE MAY CONTINUE TO ACT AS A SOURCE OF CONTAMINATION. THEREFORE, THE ACTUAL LENGTH OF TIME FOR AQUIFER CLEANUP WILL BE GREATER THAN THAT CALCULATED ABOVE. FOR LONG-TERM BUDGETARY PURPOSES, THE DURATION OF AQUIFER CLEANUP IS PROJECTED TO BE BETWEEN 7 TO 20 YEARS. A MORE ACCURATE ESTIMATE OF AQUIFER CLEANUP TIME WOULD BE POSSIBLE PROVIDED GROUND WATER REMEDIATION IS MONITORED AND RESULTS EVALUATED. THUS, A LONG-TERM MONITORING PROGRAM (SECTION 7.2.6.3) IS NEEDED TO ESTABLISH THE PERFORMANCE OF THE REMEDIATION IN ORDER TO ASSURE THAT GROUND WATER CLEANUP OBJECTIVES ARE ACHIEVED.

HYDRAULIC TESTING OF WELL HL-7 HAS SHOWN THAT DURING THE WINTER MONTHS, WHEN GROUND WATER LEVELS ARE HIGHEST, IT IS POSSIBLE TO EXTRACT 20 GPM FROM WELL HL-7 (GEOSYSTEM, MARCH 1986). TO ACCOMMODATE HIGHER EXTRACTION RATES, DISCHARGE OF TREATED WATER INTO THE SANITARY SEWER WOULD BE REQUIRED.

BECAUSE OF THE OCCASIONAL APPEARANCE OF CHROMIUM IN WELL CWP-8, LOCATED TO THE EAST OF THE SLURRY, EXTRACTION FROM WELL CWP-8 IS PROPOSED. AT THE SAME TIME, THE PUMPING RATE OF WELL HL-7 MAY BE INCREASED TO PROVIDE A MORE EFFECTIVE HYDRAULIC BARRIER. EXTRACTION FROM WELL CWP-8, HOWEVER, WILL BE EFFECTIVE IN REDUCING OR ELIMINATING THE SOURCE OF CHROMIUM TO OFF-SITE AREAS. THE EXTRACTED WATER SHALL BE TRANSFERRED THROUGH A 3-INCH LINE TO THE SUMP, AS SHOWN IN FIGURE 19. THE WATER WILL BE TREATED AS DESCRIBED EARLIER. BASED ON CWP'S EXPERIENCE, DURING WET SEASONS IT IS POSSIBLE TO EXTRACT 3 TO 5 GPM CONTINUOUSLY FROM WELL CWP-8.

BECAUSE OF THE OCCASIONAL PRESENCE OF DISSOLVED CHROMIUM IN WELL AT-2 ABOVE 0.05 MG/L, A CONTINGENCY PLAN HAS BEEN DEVELOPED TO INITIATE OFF-SITE GROUND WATER EXTRACTION, IF NEEDED. THE CRITERIA FOR INITIATION OF OFF-SITE EXTRACTION ARE CURRENTLY BEING DEVELOPED BY THE REGULATORY AGENCIES, DEPENDING ON THE PERSISTENCE OF CHROMIUM ABOVE A PRESCRIBED CONCENTRATION.

THE OFF-SITE EXTRACTION PROGRAM SHALL INCLUDE PUMPING FROM WELL AT-2 OR A NEW EXTRACTION WELL IN THE SAME VICINITY. THE EXTRACTED WATER SHALL BE TRANSFERRED, VIA A 3-INCH UNDERGROUND PVC PIPE, TO THE ON-SITE SUMP, AS SHOWN IN FIGURE 19. THE OFF-SITE GROUND WATER QUALITY DATA INDICATE THAT PUMPING FROM WELL AT-2 WOULD MOST LIKELY BE INTERMITTENT, IF REQUIRED AT ALL.

BASED ON THE ABOVE CONSIDERATIONS AND AGENCIES PARTICIPATION IN REMEDIAL ALTERNATIVE SELECTION, A SUMMARY OF GROUND WATER REMEDIAL ACTION ALTERNATIVES SUGGESTED BY DHS IS PRESENTED IN TABLE 17. ALTERNATIVE NO. GW-3, WHICH INCLUDES HYDRAULIC CONTROL COMBINED WITH EXISTING PHYSICAL CONTAINMENT, IS FAVORED BY DHS.

7.2.4 ELECTROCHEMICAL TREATMENT OF GROUND WATER

EXTRACTED GROUND WATER IN EXCESS OF CWP'S WATER REQUIREMENTS SHALL BE TREATED USING THE EXISTING ELECTROCHEMICAL UNIT AT THE SITE. THIS UNIT IS MANUFACTURED BY ANDCO ENVIRONMENTAL SERVICES (ANDCO) AND IS CAPABLE OF HANDLING UP TO 150 GPM. HOWEVER, FOR GREATER EFFICIENCY, THE FLOW RATE SHALL BE MAINTAINED BELOW 50 GPM.

AS SHOWN IN FIGURE 19, THE EXTRACTED GROUND WATER SHALL BE PUMPED TO THE ON-SITE, CONCRETE-LINED SUMP, FROM WHICH IT WILL BE TRANSFERRED TO THE TREATMENT UNIT FOR PROCESSING. AFTER PROCESSING, THE WATER WILL ENTER THE HOLDING TANKS FOR PRECIPITATION AND RETREATMENT. SUBSEQUENTLY, THE WATER SHALL BE TRANSFERRED TO THE 330,000-GALLON TANK FOR SAMPLING PRIOR TO DISCHARGE. FROM THIS TANK, THE WATER WILL BE PUMPED THROUGH A 4-INCH PVC PIPELINE, PARALLEL TO TAYLOR DRIVE, AND INTO THE SEWER MAIN AT PLANT ROAD.

THE ANDCO CHROMATE REMOVAL SYSTEM EMPLOYS A PATENTED ELECTROCHEMICAL PROCESS DESIGNED TO REDUCE TOTAL CHROMIUM CONCENTRATIONS TO LESS THAN 0.05 MG/L. THE PROCESS REDUCES SOLUBLE HEXAVALENT CHROMIUM TO TRIVALENT CHROMIUM, WHICH IS PRECIPITATED AS HYDROXIDE, AS DISCUSSED IN SECTION 7.1.3.1. THE PRECIPITATE CAN THEN BE REMOVED FROM THE WASTE STREAM BY FILTRATION OR SEDIMENTATION, YIELDING AN EFFLUENT CONTAINING LESS THAN 0.05 MG/L CHROMIUM. TESTS PERFORMED BY CWP HAVE DEMONSTRATED THAT THE EFFLUENT CONCENTRATION OF CHROMIUM IS GENERALLY LESS THAN 0.04 MG/L. SELECTED DATA OBTAINED FROM CWP ARE AS FOLLOWS:

DATE	INFLUENT CONCENTRATION (MG/L)	EFFLUENT CONCENTRATION (MG/1)
3/06/84	5.3	0.02
13/05/84	6.8	0.02
11/06/84 (SAMPLE I)	169	0.02
13/06/84 (SAMPLE 2)	160	0.07

THE ANDCO CHROMATE REMOVAL SYSTEM CONSISTS OF TWO ELECTROCHEMICAL CELLS CONNECTED IN SERIES, TWO SEPARATE DC POWER SOURCES CONTAINED IN ONE CABINET, AND AN ACID WASH SYSTEM. THE CELL HOUSINGS AND ACID TANK ARE CONSTRUCTED OF FIBERGLASS AND ALL INTERCONNECTING PIPING IS OF PVC. THE INCOMING STREAM PASSES INTO THE FIRST CELL VIA A 3-INCH LINE WHICH INCLUDES A FLOW METER AND A PRESSURE GAUGE. THE STREAM THEN PASSES THROUGH THE SECOND CELL AND EXITS VIA A THREE-WAY VALVE FOR DIRECT DISCHARGE FROM THE TREATMENT STREAM. A SECOND PRESSURE GAUGE IS INCLUDED IN THE DISCHARGE LINE. A STRAINER AND GAS RELIEF VALVE ARE FITTED TO THE TOP OF EACH CELL TO PROVIDE A RELEASE FOR HYDROGEN GENERATED DURING THE ELECTROCHEMICAL PROCESS AND SHUTOFF DURING ACID WASHING. THE BOTTOM OF EACH CELL IS PIPED TO THE ACID PUMP FOR DRAINAGE PRIOR TO AND AFTER ACID WASHING AND FOR DRAINAGE PRIOR TO CELL REPLACEMENT (ANDCO, JUNE 1987).

THE ACID WASH SYSTEM CONSISTS OF AN ACID STORAGE TANK, ACID PUMP, AND INTERCONNECTING PIPING TO ALLOW ACID WASHING OF THE CELLS ON A DAILY BASIS. ACID WASHING PREVENTS COATING OF THE ELECTRODE SURFACES AND THE CORRESPONDING LOSS IN TREATMENT SYSTEM EFFICIENCY. THE PROCEDURE IS RELATIVELY SIMPLE TO PERFORM AND REQUIRES ONLY ABOUT IS MINUTES PER DAY TO ACCOMPLISH. TWO TO THREE TIMES A WEEK, THE ACID CONCENTRATION SHOULD BE CHECKED AND KEPT TO 8 TO 10 PERCENT BY THE ADDITION OF FRESH MURIATIC ACID. ON A MONTHLY BASIS, THE SPENT ACID CAN BE NEUTRALIZED AND BLED INTO THE DISCHARGE LINE AND NEW ACID MADE UP. THE ELECTRODE PLATES HAVE A NORMAL LIFE OF ABOUT ONE MILLION GALLONS AT AN INFLUENT CONCENTRATION OF 10 TO 11 MG/L OF CR(VI).

SUBSEQUENT TO THE INITIAL TREATMENT, THE WATER SHALL BE TRANSFERRED TO HOLDING TANKS, LOCATED NORTH OF THE TANK FARM, WHERE THE METAL HYDROXIDES ARE PRECIPITATED. AFTER PRECIPITATION IS COMPLETED, THE WATER COULD BE PASSED THROUGH THE TREATMENT UNIT A SECOND TIME TO ASSURE COMPLIANCE WITH EFFLUENT LIMITATIONS. THE EFFLUENT SHALL BE TRANSFERRED TO THE 330,000-GALLON TANK FOR TESTING AND STORAGE PRIOR TO DISCHARGE. THE TANK IS CONNECTED TO THE SANITARY SEWER LOCATED AT THE INTERSECTION OF TAYLOR DRIVE AND PLANT ROAD (FIGURE 19). THE RESULTING SLUDGE SHALL BE HANDLED ACCORDING TO THE APPROPRIATE EPA AND DHS REGULATIONS.

7.2.5 WATER REUSE/DISCHARGE TO THE UKIAH SEWAGE TREATMENT PLANT OR REINJECTION

EXTRACTED GROUND WATER WILL BE RECYCLED INTO CWP'S WOOD PRESERVING OPERATIONS TO THE EXTENT POSSIBLE. EXCESS GROUND WATER WHICH CANNOT BE RECYCLED INTO THE WOOD PRESERVING OPERATIONS WILL BE TREATED ELECTROCHEMICALLY, AS DESCRIBED IN THE PREVIOUS SECTION, AND DISCHARGED. AMONG THE VIABLE DISCHARGE OPTIONS CONSIDERED IN SECTION 7.1.4, DISCHARGE INTO THE SANITARY SEWER DURING THE WET MONTHS OR REINJECTION DURING THE DRY MONTHS APPEAR TO BE THE MOST PRACTICAL METHODS. DISCHARGE TO THE UKIAH SEWAGE TREATMENT PLANT MUST MEET PRETREATMENT REQUIREMENTS. ON DECEMBER 23, 1987, A DRAFT PERMIT TO DISCHARGE PRETREATED GROUND WATER WAS ISSUED BY THE CITY. THE DRAFT DOCUMENT OUTLINES THE REQUIREMENTS WHICH NEED TO BE MET PRIOR TO ALLOWING CWP TO DISCHARGE THE TREATED GROUND WATER. CWP HAS PROPOSED TO DISCHARGE TREATED WATER IN A BATCH BODE AFTER MONITORING. THE INITIAL MONITORING PROGRAM, AS SPECIFIED BY THE CITY, IS PRESENTED IN TABLE 15. CWP IS CURRENTLY REVIEWING THE DRAFT DOCUMENT AND PREPARING A RESPONSE.

7.2.6 MONITORING

MONITORING IS AN INTEGRAL PART OF REMEDIATION TO DOCUMENT THE PERFORMANCE AND EFFICIENCY OF THE EXTRACTION/TREATMENT SYSTEM. BASED ON THE MONITORING RESULTS, RECOMMENDATIONS AND MODIFICATIONS SHALL BE MADE FOR FURTHER SITE IMPROVEMENTS, AS APPROPRIATE. VARIOUS ELEMENTS OF THE PROPOSED MONITORING PROGRAM ARE DESCRIBED BELOW.

7.2.6.1 AIR QUALITY MONITORING

THE RECOMMENDED REMEDIAL ACTION DOES NOT REQUIRE AIR MONITORING; HOWEVER, AS PART OF ROUTINE WOOD PRESERVING OPERATIONS, AIR QUALITY IS MONITORED ON A PERIODIC BASIS. AIR QUALITY MONITORING PERTINENT TO RAP REQUIREMENTS SHALL BE EVALUATED IF CONTAMINATED SOIL IS TO BE EXCAVATED FOR REMEDIATION OR OTHERWISE DISTURBED. THE AIR QUALITY MONITORING PLAN WILL BE PART OF THE OVERALL HEALTH AND SAFETY PLAN AND ACCORDING TO OSHA REQUIREMENTS.

7.2.6.2 STORM WATER MONITORING

STORM WATER MONITORING, AS SPECIFIED BY THE RWQCB, SHALL BE PERFORMED AT STATIONS NE, NW, AND C-100, THE LOCATIONS OF WHICH ARE SHOWN IN FIGURE 2. THESE LOCATIONS HAVE BEEN SELECTED TO PROVIDE AN INDICATION OF THE QUALITY OF SURFACE RUNOFF FROM THE CWP SITE. THIS IS OF IMPORTANCE, AS THE SURFACE DRAINAGE SYSTEM ULTIMATELY DRAINS INTO THE RUSSIAN RIVER. STORM WATER SAMPLES SHALL BE COLLECTED ONCE PER MONTH DURING ANY PRECIPITATION EVENT SUFFICIENT TO PRODUCE A FLOW OF WATER IN THE SUBJECT DITCHES. THE SAMPLES SHALL BE ANALYZED FOR DISSOLVED TOTAL CHROMIUM AND ARSENIC. STORM WATER MONITORING RESULTS SHALL BE COMPILED AND REPORTED TO THE RWQCB AS SPECIFIED IN REVISED MONITORING AND REPORTING PROGRAM NO. 85-101 (RWQCB MAY 1987). THE RESULTS SHALL BE EVALUATED AND RECOMMENDATIONS AND MODIFICATIONS REGARDING OVERALL FACILITY IMPROVEMENTS SHALL BE MADE AS APPROPRIATE.

7.2.6.3 GROUND WATER MONITORING

A GROUND WATER MONITORING PROGRAM (RWQCB, MAY 1987) IS IN EFFECT TO EVALUATE THE GROUND WATER FLOW REGIME AND THE DISTRIBUTION OF CHROMIUM THROUGHOUT THE STUDY AREA. MONITORING INCLUDES GROUND WATER LEVEL MEASUREMENTS AND GROUND WATER QUALITY SAMPLING/ ANALYSIS. THE GROUND WATER MONITORING RESULTS SHALL BE USED TO EVALUATE THE EFFECTIVENESS OF THE HYDRAULIC CONTROL MEASURES IMPLEMENTED. RECOMMENDATIONS REGARDING ADDITIONAL MITIGATION MEASURES WILL BE MADE AS APPROPRIATE.

THE GROUND WATER SAMPLES WILL BE ANALYZED FOR TOTAL CHROMIUM AS SPECIFIED IN REVISED MONITORING AND REPORTING PROGRAM NO. 85-101, (RWQCB, MAY 1987). THE MONITORING SHALL BE PERFORMED ACCORDING TO THE PROCEDURES OUTLINED IN THE "GROUND WATER/STORM WATER MONITORING PROTOCOL" (GEOSYSTEM, AUGUST 1987, OR ITS SUBSEQUENT REVISIONS) PREPARED SPECIFICALLY FOR THE CWP FACILITY.

THE RESULTS OF THE GROUND WATER MONITORING SHALL BE REVIEWED ON A QUARTERLY BASIS AND REPORTED TO THE RWQCB AS REQUIRED BY REVISED MONITORING AND REPORTING PROGRAM NO. 85-101 (RWQCB, MAY 1987). BASED ON THE EVALUATION OF THE MONITORING RESULTS, RECOMMENDATIONS AND MODIFICATIONS SHALL BE MADE AS APPROPRIATE AND SUBJECT TO RWQCB APPROVAL.

7.2.6.4 TREATMENT SYSTEM MONITORING

DURING THE OPERATION OF THE ELECTROCHEMICAL UNIT, THE INFLUENT AND EFFLUENT CONCENTRATIONS SHALL BE MONITORED FOR HEXAVALENT CHROMIUM AND TOTAL CHROMIUM. THE MONITORING FREQUENCY SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE UKIAH SEWAGE TREATMENT PLANT, AS OUTLINED IN TABLE 15.

7.3 REASONS FOR SELECTION OF THE RECOMMENDED REMEDIAL ACTION

ENVIRONMENTAL AND PUBLIC HEALTH CRITERIA AND COST WERE THE PRINCIPAL CONSIDERATIONS IN THE SELECTION OF THE PROPOSED REMEDIAL ACTION PLAN. SPECIFIC REASONS FOR SELECTION OF VARIOUS COMPONENTS OF THE PLAN ARE AS FOLLOWS:

- PAVING OF THE AREAS OF SOIL IN WHICH HIGHER CHROMIUM CONCENTRATIONS HAVE BEEN MEASURED PREVENTS SURFACE WATER INFILTRATION AND REDUCES THE POTENTIAL FOR LEACHING OF CHROMIUM.

- ON-SITE TREATMENT OF SOIL AFTER SITE CLOSURE PROVIDES A PERMANENT REMEDY FOR THE CONTAMINATED SOIL.

- EXTRACTION FROM RECOVERY WELL CWP-18 REMOVES CHROMIUM-CONTAINING GROUND WATER IN AREAS WHERE CHROMIUM CONCENTRATIONS ARE HIGHEST, THUS REDUCING THE SOURCE TO DOWNGRADIENT AREAS.

- EXTRACTION FROM WELL HL-7, IN COMBINATION WITH THE SLURRY CUTOFF WALL, IS EFFECTIVE IN CONTAINING THE CHROMIUM PLUME ON SITE AND GRADUALLY REMEDIATING THE AQUIFER.

- EXTRACTION FROM WELL CWP-8 WOULD CONTAIN ANY RESIDUAL CHROMIUM TO THE EAST OF THE SLURRY WALL AND PREVENT FURTHER DOWNGRADIENT MIGRATION TO OFFSITE AREAS.

- USE OF THE ELECTROCHEMICAL UNIT IS AN ENVIRONMENTALLY AND ECONOMICALLY SOUND APPROACH FOR GROUND WATER TREATMENT.

- DISCHARGE OF THE TREATED WATER INTO THE UKIAH SEWAGE TREATMENT PLANT IS THE MOST FLEXIBLE AND ENVIRONMENTALLY SOUND APPROACH.

- THE PROPOSED MONITORING PLAN PROVIDES SUFFICIENT DATA TO DEMONSTRATE THE EFFECTIVENESS OF THE REMEDIAL ACTION PLAN AND TO IDENTIFY THE NEED FOR ADDITIONAL REMEDIAL ACTIONS, IF ANY.

THE REASONS FOR REJECTING OTHER ALTERNATIVES ARE BROADLY CATEGORIZED AS FOLLOWS:

- MARGINAL ENVIRONMENTAL ENHANCEMENT AT THE EXPENSE OF AN "ORDER OF MAGNITUDE" INCREASE IN COST, AS ILLUSTRATED BY COST ESTIMATES FOR SOIL REMOVAL.

- ENVIRONMENTAL UNACCEPTABILITY AND LACK OF PROVEN TECHNOLOGY FOR ALL HYDRAULIC CONTROL MEASURES EXCEPT THE SELECTED OPTION.

- TECHNICAL DIFFICULTIES FOR GROUND WATER INJECTION DURING WET SEASONS.

- INEFFICIENCY AND RELATIVE HIGH COST ASSOCIATED WITH OTHER TREATMENT TECHNOLOGIES COMPARED WITH THE ELECTROCHEMICAL PROCESS.

7.4 ENVIRONMENTAL EFFECTS OF THE SELECTED REMEDIAL ACTION

IN GENERAL, THE SELECTED REMEDIAL PLAN WILL MINIMIZE POTENTIAL ADVERSE IMPACTS ON HUMAN HEALTH AND THE ENVIRONMENT. THE SPECIFIC FEATURES OF THE REMEDIAL PLAN, WITH RESPECT TO ENVIRONMENTAL EFFECTS, ARE DESCRIBED BELOW.

7.4.1 CONTROL OF CONTAMINATED SOIL

ROUTINE MAINTENANCE OF SURFACE PAVING OVER AREAS OF SOIL CONTAMINATION SHALL PREVENT DIRECT EXPOSURE TO CONTAMINATED SOIL AND MINIMIZE THE INFILTRATION OF SURFACE WATERS. CONSEQUENTLY, THE TOP 1 TO 2 FEET OF THE SOIL PROFILE, WHICH HAVE BEEN SHOWN TO CONTAIN ELEVATED CONCENTRATIONS OF CHROMIUM AND ARSENIC, WILL NOT ACT AS A MAJOR SOURCE OF GROUND WATER CONTAMINATION. THE POST CLOSURE REMEDIATION PROVIDES A PERMANENT REMEDY FOR THE ON-SITE CONTAMINATED SOILS.

7.4.2 PLUME CONTROL

THE TWO MAJOR OBJECTIVES OF PLUME CONTROL ARE PREVENTING OFF-SITE MIGRATION AND REMEDIATING EXISTING CONTAMINATION IN THE ON-SITE WATER-BEARING ZONE. OFF-SITE MIGRATION IS CONTROLLED BY THE COMBINATION OF THE SLURRY CUTOFF VAIL AND EXTRACTION OF GROUND WATER FROM WELLS HL-7 AND CWP-8. ON-SITE REMEDIATION IS ACCOMPLISHED BY GROUND WATER EXTRACTION FROM WELLS HL-7 AND CWP-18. WATER QUALITY DATA HAVE DEMONSTRATED THAT THESE HYDRAULIC CONTROL MEASURES HAVE BEEN EFFECTIVE IN PREVENTING THE OFF-SITE MIGRATION OF CHROMIUM. SUBSEQUENT TO CONSTRUCTION OF THE SLURRY WALL IN OCTOBER 1983, CHROMIUM CONCENTRATIONS IN OFF-SITE WELLS HAVE GENERALLY DECREASED WITH TIME, AS DESCRIBED IN SECTION 4.5.3.

BASED ON THE CURRENT CHROMIUM CONCENTRATIONS IN OFF-SITE WELLS AND THE CONTINUING TREND OF DECREASING CHROMIUM CONCENTRATIONS, NO REMEDIATION IS PROPOSED FOR OFF-SITE AREAS. HOWEVER, A CONTINGENCY PLAN IS DEVELOPED TO ADDRESS OFF-SITE REMEDIATION WHEN THE CRITERIA FOR SUCH REMEDIATION ARE ESTABLISHED BY THE REGULATORY AGENCIES. TO DEMONSTRATE THE POTENTIAL ENVIRONMENTAL IMPACTS OF SELECTION OF THE "NO ACTION" ALTERNATIVE FOR OFF-SITE AREAS, THE TRANSPORT OF CHROMIUM WAS SIMULATED USING A TWO-DIMENSIONAL AREAL MODEL (GEOSYSTEM, APRIL 1987). DETAILS OF THIS MODELING EFFORT ARE PRESENTED IN APPENDIX E. THE MODEL RESULTS DEMONSTRATED THE FOLLOWING:

- UNDER PRESENT CONDITIONS, DOWNGRADIENT RECEPTORS WILL NOT BE ADVERSELY IMPACTED.

- DISPERSION AND ATTENUATION MECHANISMS WILL CONTINUE TO REDUCE CHROMIUM CONCENTRATIONS IN DOWNGRADIENT AREAS.

7.4.3 MONITORING

THE PROPOSED MONITORING PROGRAM IS DESIGNED TO DETECT ANY SIGNIFICANT ENVIRONMENTAL CHANGES AND TO PROVIDE EARLY WARNING TO THE RESPONSIBLE PARTIES. USING THE MONITORING DATA, THE EFFECTIVENESS OF THE PROPOSED REMEDIAL ACTION PLAN SHALL BE EVALUATED. THIS EVALUATION SHALL BE USED AS A BASIS FOR MODIFICATION OF THE REMEDIAL ACTION PLAN, IF NECESSARY.

7.5 APPLICABLE LAWS AND REGULATIONS

THE CWP SITE IS INCLUDED ON THE STATE SUPERFUND AND NATIONAL PRIORITY LISTS AND IS, THUS, SUBJECT TO BOTH STATE AND FEDERAL LAWS AND REGULATIONS. ALTHOUGH THE MORE FORMAL AND SYSTEMATIC SOIL AND GROUND WATER QUALITY INVESTIGATIONS AT THE SITE BEGAN IN JUNE 1980, A CERTAIN AMOUNT OF MONITORING WAS PERFORMED IN THE 1970S BY THE RWQCB. DURING THE EARLY PHASES OF THE INVESTIGATIONS, HOWEVER, MANY OF THE CURRENT REGULATIONS AND GUIDELINES WERE NOT IN EFFECT. THEREFORE, INVESTIGATION AND REMEDIATION ACTIVITIES WERE NOT ALWAYS PERFORMED IN ACCORDANCE WITH THE STATE AND FEDERAL LAWS CURRENTLY IN EFFECT. CERTAIN ACTIVITIES WERE PERFORMED BY CWP WITHOUT AUTHORIZATION OF THE REGULATORY AGENCIES (APPENDIX A).

AS REQUIRED BY THE NATIONAL CONTINGENCY PLAN (NCP 1985) AND SUPERFUND AMENDMENT AND REAUTHORIZATION ACT (SARA 1986), APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) HAVE BEEN USED AS A GUIDE TO EVALUATE THE APPROPRIATE EXTENT OF SITE CLEANUP, SELECT APPROPRIATE REMEDIAL ACTION ALTERNATIVES, AND HAS BEEN AND WILL BE USED IN IMPLEMENTATION AND OPERATION OF THE SELECTED REMEDIAL ACTION. AS REQUIRED BY SARA, STATE REQUIREMENTS THAT ARE MORE STRINGENT THAN FEDERAL REQUIREMENTS MUST GENERALLY BE ATTAINED IN IMPLEMENTATION OF REMEDIAL ACTIONS. THESE LAWS AND REGULATIONS ARE AS FOLLOWS:

- COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA) OF 1980, AS AMENDED BY THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) OF 1986.

- RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) OF 1976, AMENDED BY THE HAZARDOUS AND SOLID WASTE AMENDMENTS OF 1984 (RCRA OR HSWA).

- SAFE DRINKING WATER ACT.

- CALIFORNIA CODE OF REGULATIONS, TITLE 22, DIVISION 4: ENVIRONMENTAL HEALTH (CHAPTER 1, ARTICLE 1; CHAPTER 2, ARTICLE 1; CHAPTER 30), JULY 1986.

- CALIFORNIA HEALTH AND SAFETY CODE.

- NORTH COASTAL BASIN WATER QUALITY CONTROL PLAN ADOPTED BY THE RWQCB.

- ALL ORDERS, INCLUDING SPECIFICATIONS, PROVISIONS, PROHIBITIONS, AND REQUIREMENTS ISSUED BY THE RWQCS.

- COURT ORDER BY THE STATE OF CALIFORNIA, OFFICE OF THE ATTORNEY GENERAL.

- NATIONAL CONTINGENCY PLAN, PERTINENT HAZARDOUS WASTE REGULATIONS UNDER 40 CFR, PARTS 260 TO 265; PART 300-68, JULY 1985.

- PORTER-COLOGNE WATER QUALITY CONTROL ACT, 1969.

BASED ON A REQUEST MADE BY DHS, A DRAFT OF THE DEED OF RESTRICTION ON REAL PROPERTY IS UNDER PREPARATION AND WILL BE INCLUDED AS APPENDIX G TO THIS DOCUMENT.

#ISH
8.0 IMPLEMENTATION SCHEDULE

AS MENTIONED IN-SECTION 5.0, THE INTERIM REMEDIAL MEASURES PROGRAM HAS BEEN IN EFFECT FOR SOME TIME. THEREFORE, A NUMBER OF ELEMENTS OF THE RECOMMENDED REMEDIAL ACTION PLAN HAVE ALREADY BEEN IMPLEMENTED. ACCORDING TO CWP, PUMPS AND PIPING ASSOCIATED WITH GROUND WATER EXTRACTION FROM WELLS CWP-18, HL-7, AND CWP-8 ARE IN PLACE AND IN OPERATING CONDITION. ALSO, THE ELECTROCHEMICAL UNIT IS ON SITE AND IN OPERATING CONDITION.

SUBSEQUENT TO APPROVAL OF THE RAP, THE FOLLOWING ACTIVITIES NEED TO BE COMPLETED PRIOR TO FULL-SCALE OPERATION:

- FINAL PERMIT FROM THE CITY FOR DISCHARGE OF TREATED WATER INTO THE SANITARY SEWER.
- CONNECTING THE LINE TO THE SEWER SYSTEM.
- PERMITTING, DESIGN, AND CONSTRUCTION OF OFF-SITE EXTRACTION SYSTEM, IF NEEDED.
- SYSTEM STARTUP AND TESTING.

BECAUSE OF UNCERTAINTIES ASSOCIATED WITH THE TIME OF APPROVAL OF THE RAP AND OBTAINING THE PERMIT TO DISCHARGE INTO THE SANITARY SEWER, THE REAL TIME SCHEDULE IS NOT KNOWN. CONNECTING THE LINE TO THE SEWER SYSTEM, CONSTRUCTION OF THE OFF-SITE EXTRACTION SYSTEM, IF NEEDED, AND SYSTEM STARTUP CAN BE COMPLETED WITHIN A THREE-MONTH PERIOD.

#AFR
9.0 ALLOCATION OF FINANCIAL RESPONSIBILITY AND PROVISIONS FOR FINANCIAL ASSURANCE

ALLOCATION OF FINANCIAL RESPONSIBILITY AND PROVISIONS FOR FINANCIAL ASSURANCE ARE BEING NEGOTIATED WITH THE REGULATORY AGENCIES AND WILL BE INCLUDED IN THE RAP IN THE NEAR FUTURE.

#OMR
10.0 OPERATION AND MAINTENANCE REQUIREMENTS

OPERATION AND MAINTENANCE (O&M) REQUIREMENTS WILL BE DEVELOPED SUBSEQUENT TO SYSTEM DESIGN, INSTALLATION, AND STARTUP. THESE REQUIREMENTS SHALL BE OUTLINED IN AN OPERATION AND MAINTENANCE MANUAL. HOWEVER, THE GENERAL O&M REQUIREMENTS RELATED TO THE FOLLOWING COMPONENTS AND FEATURES OF THE RECOMMENDED REMEDIAL ACTION ARE BRIEFLY DESCRIBED.

- GROUND WATER EXTRACTION
- GROUND WATER TREATMENT
- GENERAL SYSTEM INSPECTION AND MONITORING
- GENERAL SAFETY PROCEDURES
- EVALUATION OF SYSTEM EFFECTIVENESS
- REPORTING.

10.1 GROUND WATER EXTRACTION

DURING THE STARTUP PERIOD, FLOW ADJUSTMENTS SHALL BE MADE IN ACCORDANCE WITH CWP'S WATER RECYCLING REQUIREMENTS AND LIMITS OF TREATED WATER DISCHARGE. HOWEVER, ATTEMPTS WILL BE MADE TO MAXIMIZE EXTRACTION RATES FOR MORE EFFECTIVE HYDRAULIC CONTROL AND REMEDIATION. PROVISIONS MUST BE MADE TO RECORD THE EXTRACTION RATE AND CUMULATIVE FLOW FROM EACH EXTRACTION WELL.

DURING NORMAL OPERATION, THE O&M REQUIREMENTS INCLUDE FLOW ADJUSTMENT AND RECORDING, MAINTENANCE OF PUMPS AND PIPELINES, CALIBRATION OF GAUGES AND FLOW TOTALIZERS, PERIODIC SYSTEM INSPECTION, AND RECORD KEEPING. THE O&M MANUAL SHOULD PROVIDE DETAILED PROCEDURES FOR FLOW CONTROL AND DATA RECORDING DURING SYSTEM OPERATION.

10.2 GROUND WATER TREATMENT

ANDCO ENVIRONMENTAL SERVICES, INC. HAS PROVIDED CWP WITH PROCEDURES FOR OPERATING THE ELECTROCHEMICAL UNIT EXISTING AT THE SITE. SOME OF THE OPERATIONAL FEATURES OF THE UNIT ARE SUMMARIZED IN SECTION 7.2. THE ANDCO OPERATING PROCEDURES OUTLINE THE FOLLOWING STEPS WITH

SUFFICIENT DETAIL FOR IMPLEMENTATION:

- STARTUP OPERATION
- DAILY ACID WASHING AND POLARITY CHANGING
- SPENT ACID DISPOSAL
- ACID MAKEUP
- SHUTDOWN
- ELECTRODE REPLACEMENT
- PRECAUTIONS.

SINCE INSTALLATION OF THE ELECTROCHEMICAL UNIT, CWP HAS MADE SOME MODIFICATIONS TO IMPROVE ITS OPERATION. THE OPERATOR OF THE EXTRACTION/TREATMENT SYSTEM SHALL BE FAMILIAR WITH THESE MODIFICATIONS.

10.3 SYSTEM INSPECTION AND MONITORING

IT IS RECOMMENDED THAT THE GROUND WATER EXTRACTION/TREATMENT SYSTEM BE INSPECTED ONCE PER DAY. THE INSPECTION SHOULD INCLUDE THE EXTRACTION WELL PIPING AND INSTRUMENTATION; PIPELINES TRANSFERRING CONTAMINATED WATER TO THE SUMP; MAIN HEADER TO THE SEWER SYSTEM; AND TREATMENT SYSTEM UNIT, PIPES, AND INSTRUMENTATION. FLOW TOTALIZER READINGS AT THE EXTRACTION WELLS AND THE TREATMENT SYSTEM INFLUENT LINE SHOULD BE RECORDED.

SYSTEM MONITORING SHOULD BE PERFORMED ACCORDING TO THE REQUIREMENTS SET FORTH BY THE RWQCB AND THE CITY OF UKIAH, AS PROVIDED IN THE RAP AND SUPPLEMENTARY DOCUMENTS ISSUED BY THESE AGENCIES.

A DAILY OPERATION LOG SHALL BE MAINTAINED AT THE SITE TO RECORD THESE ROUTINE INSPECTIONS. THE LOG SHALL BE A BOUND, HARD-COVERED BOOK WITH NUMBERED PAGES. IN ADDITION TO FLOW TOTALIZER READINGS AND OTHER OBSERVATIONS, THE OPERATOR(S) SHALL RECORD ANY PROBLEMS ENCOUNTERED, THE CORRECTIVE ACTIONS TAKEN, AND ANY OTHER RELEVANT INFORMATION. EACH ENTRY SHALL INCLUDE THE TIME, DATE, AND THE OPERATOR'S NAME OR INITIALS. THE INFORMATION IN THE DAILY OPERATION LOG WILL BE USED IN PREPARING MONTHLY REPORTS TO TEE RWQCB AND IN EVALUATING THE EFFECTIVENESS OF THE GROUND WATER EXTRACTION AND TREATMENT SYSTEM.

INFORMATION RELATED TO WATER QUALITY SAMPLING SHALL ALSO BE RECORDED IN THE LOG BOOK. THIS INFORMATION SHOULD INCLUDE, AT A MINIMUM:

- SAMPLE LOCATIONS
- DATE AND TIME OF SAMPLE COLLECTION
- NUMBER OF CONTAINERS COLLECTED
- ANALYSES REQUESTED
- NAME OF SAMPLING PERSONNEL
- COMMENTS.

COMMENTS MAY INCLUDE SUCH THINGS AS ODORS OBSERVED, APPEARANCE OF THE WATER (TURBIDITY, COLOR, ETC.), WEATHER CONDITIONS, OR OTHER PERTINENT INFORMATION.

10.4 GENERAL SAFETY PROCEDURES

THE GENERAL SAFETY PROCEDURES PERTINENT TO THE RECOMMENDED REMEDIAL ACTION ARE AS FOLLOWS:

- OPERATING EQUIPMENT SHALL BE CHECKED FREQUENTLY FOR SIGNS OF LEAKAGE, CORROSION, OR DAMAGE. ANY SUCH DEFECTS NOTED SHALL BE REPAIRED OR OTHERWISE CORRECTED BEFORE ANY ADVERSE CONSEQUENCES RESULT.

- TOOLS, PIPE, AND OTHER EQUIPMENT SHALL NOT BE LEFT LYING AROUND THE EXTRACTION WELL HEADS OR AROUND THE ELECTROCHEMICAL TREATMENT UNIT.

- WASTE MATERIAL AND SLUDGE SHOULD BE PLACED IN A SUITABLE RECEPTACLE OR REMOVED FROM THE SITE ACCORDING TO THE APPROPRIATE REGULATIONS.

- ANY SPILLS OF CONTAMINATED GROUND WATER SHALL BE CLEANED UP IMMEDIATELY AND REPORTED, AS APPROPRIATE.

IT IS RECOMMENDED THAT ONLY PERSONS FAMILIAR WITH THE GROUND WATER EXTRACTION AND TREATMENT SYSTEM PERFORM OPERATION AND MAINTENANCE ACTIVITIES.

10.5 EVALUATION OF SYSTEM EFFECTIVENESS

BASED ON GROUND WATER MONITORING DATA, THE EFFECTIVENESS OF THE EXTRACTION/TREATMENT SYSTEM SHALL BE EVALUATED. THE EVALUATION WILL INCLUDE THE HYDRAULIC RESPONSE OF THE WATER-BEARING ZONES TO EXTRACTION AND WATER QUALITY CHANGES WITH TIME. THIS TYPE OF EVALUATION IS USUALLY PERFORMED ON AN ANNUAL BASIS. THE RESULTS OF SUCH EVALUATIONS WILL BE USED TO MAKE PROJECTIONS FOR AQUIFER CLEANUP AND MODIFICATIONS TO THE REMEDIATION STRATEGY, IF NECESSARY.

10.6 SITE INSPECTION

THE SITE SHALL BE INSPECTED PERIODICALLY TO IDENTIFY POTENTIAL MIGRATION PATHWAYS OF THE CONTAMINANTS AND TAKE APPROPRIATE CORRECTIVE ACTIONS. THE ASPHALT COVER, PARTICULARLY IN RETORT AND SUMP AREAS, SHALL BE CAREFULLY INSPECTED AND REPAIRED ACCORDINGLY TO PREVENT SURFACE INFILTRATION. OTHER SURFACE FEATURES SHALL BE INSPECTED TO PREVENT MIGRATION OF WOOD PRESERVING CHEMICALS INTO SURFACE WATERS.

10.7 REPORTING

THE REPORTING REQUIREMENTS DURING THE IMPLEMENTATION OF THE RECOMMENDED REMEDIAL ACTION WILL BE IN ACCORDANCE WITH THE GUIDELINES AND PROCEDURES SET FORTH BY THE RWQCB, DHS, EPA, THE CITY, AND OTHER REGULATORY AGENCIES. MONTHLY PROGRESS REPORTS SHALL BE PREPARED AND SUBMITTED TO THE AGENCIES. THE PROGRESS REPORTS WILL PRESENT A SUMMARY OF THE WORK PERFORMED, DATA COLLECTED, AND INTERPRETATIONS MADE IN THE PRECEDING MONTH. IF CHANGES NEED TO BE MADE, THE PROGRESS REPORTS WILL OUTLINE THE PROPOSED CHANGES FOR THE AGENCIES' INFORMATION AND APPROVAL. AN ANNUAL REPORT ALL BE PREPARED SUMMARIZING THE DATA OBTAINED AND THE ASSOCIATED FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS.

#TA

TABLE 10
WATER QUALITY CRITERIA SUMMARY

NOTE: THIS CHART IS FOR GENERAL INFORMATION; PLEASE USE CRITERIA DOCUMENTS OR DETAILED SUMMARIES IN "QUALITY CRITERIA FOR WATER 1986" FOR REGULATORY PURPOSES.

CONCENTRATIONS IN UG/L

COMPOUND	PRIORITY POLLUTANT	EPA CARCINOGENICITY CLASSIFICATION (4)
ARSENIC	Y	A
ARSENIC (PENT)	Y	A
ARSENIC (TRI)	Y	A
CHROMIUM (HEX)	Y	A
CHROMIUM (TRI)	N	A
COPPER	Y	D

COMPOUND	FRESH ACUTE CRITERIA	FRESH CHRONIC CRITERIA
ARSENIC		
ARSENIC (PENT)	850(2)	48(2)
ARSENIC (TRI)	360	190
CHROMIUM (HEX)	18	11
CHROMIUM (TRI)	1,700(3)	210(3)
COPPER	18(3)	12(3)

COMPOUND	MARINE ACUTE CRITERIA	MARINE CHRONIC CRITERIA
ARSENIC		
ARSENIC (PENT)	2,319(2)	13(2)
ARSENIC (TRI)	69	36
CHROMIUM (HEX)	1,100	50
CHROMIUM (TRI)	10,300(2)	
COPPER	2.9	2.9

TABLE 10 (CONT)

UNITS PER LITER

COMPOUND	WATER AND FISH INGESTION	FISH CONSUMPTION ONLY
ARSENIC	2.2 NG(1)	17.5 NG (1)
ARSENIC (PENT)		
ARSENIC (TRI)		
CHROMIUM (HEX)	50 UG	
CHROMIUM (TRI)	170 MG	3,433 MG
COPPER		

COMPOUND	DRINKING WATER M.C.L
ARSENIC	0.05 MG
ARSENIC (PENT)	
ARSENIC (TRI)	
CHROMIUM (HEX)	0.05 MG
CHROMIUM (TRI)	0.05 MG
COPPER	

COMPOUND	DATE REFERENCE	NO. OF STATES WITH AQUATIC LIFE STANDARD
ARSENIC	1980FR	21
ARSENIC (PENT)	1985FR	21
ARSENIC (TRI)	1985FR	21
CHROMIUM (HEX)	1985FR	24
CHROMIUM (TRI)	1985FR	24
COPPER	1985FR	2

NOTES: 1) INSUFFICIENT DATA TO DEVELOP CRITERIA. VALUE PRESENTED IS THE LOWEST OBSERVED EFFECT LEVEL (LOEL).

2) HUMAN HEALTH CRITERIA FOR CARCINOGENS REPORTED FOR THREE RISK LEVELS. VALUE PRESENTED IN THE (10-6) RISK LEVEL.

3) HARDNESS DEPENDENT CRITERIA (100 MG/L USED)

4) GROUP A DENOTES "HUMAN CARCINOGEN" AND GROUP D DENOTES " NOT CLASSIFIABLE."

REFERENCE: US ENVIRONMENTAL PROTECTION AGENCY, MAY 1, 1987, "QUALITY CRITERIA FOR WATER 1986," UPDATE #32, OFFICE OF WATER REGULATIONS AND STANDARDS, CRITERIA AND STANDARDS DIVISION.

TABLE 11

PUBLIC HEALTH PROTECTION STANDARDS

MEDIUM	CHEMICAL SPECIES/FORM	RECOMMENDED OR ESTABLISHED STANDARD	REFERENCE
DRINKING WATER	CR(VI)	0.05 MG/L	US PUBLIC HEALTH STANDARDS, 1962
DRINKING WATER	TOTAL CR	0.05 MG/L	NAS, 1974; US EPA, 1976
WORKPLACE AIR	CARCINOGENIC FORMS	0.001 MG/M(3)	NIOSH, 1975
WORKPLACE	NONCARCINOGENIC	0.025 MG/M(3)	TWA ORNIOSH, 1975
AIR	FORMS OF CR(VI)	0.05 MG/M(3)	CEILING
AMBIENT WATER	CR(VI)	0.05 MG/L	US EPA, 1980
AMBIENT WATER	CR(III)	0.170 MG/L	US EPA, 1980
AMBIENT AIR (?)	(?)	0.15 UG/M(3)	CARB RISK VALUE

TABLE 12

ESTIMATED COST OF VARIOUS REMEDIAL ACTION ALTERNATIVES
(ALL AMOUNTS ARE IN THOUSANDS OF DOLLARS)

	SOIL REMOVAL AND OFF-SITE DISPOSAL (4 MONTHS)	SOIL REMOVAL AND ON-SITE TREATMENT (1 YEAR)	IN-SITU TREATMENT (2 YEARS)
DESIGN/CONTROL	10	NA (1)	NA (1)
MOBILIZATION	5	10 - 15	5
EXCAVATION	40 - 50	40 - 50	30 (2)
TRANSPORTATION/ DISPOSAL	1,450	500 (3)	260
HEALTH AND SAFETY	10	30	30
SUPERVISION	20	150	100
SITE RESTORATION	10	30	30
CONTRACTOR PROFIT	30 - 70	50 - 80	50 - 75
LABORATORY COSTS	30 - 50	50 - 80	50 - 75
REPORTING	30 - 40	70	70
TOTAL COSTS (5)	1,635 - 1,715	930 - 1,005 (6)	625 - 675 (7)

NOTES: (1) NA DENOTES NOT AVAILABLE; COST DEPENDS ON DESIGN REQUIREMENTS.
(2) ASPHALT REMOVAL.
(3) TREATMENT ONLY.
(5) ALL COSTS ARE ESTIMATES AND ARE INTENDED TO PROVIDE RELATIVE COST COMPARISONS FOR REMEDIATION ALTERNATIVES. INFLATION FACTOR IS NOT CONSIDERED.
(6) EXCLUDING DESIGN COSTS.
(7) EXCLUDING DESIGN AND FIELD TESTING COSTS.

	PARTIAL EXCAVATION OFF-SITE DISPOSAL (4 MONTHS)	CONTAINMENT (2 YEARS)	NO ACTION (2 YEARS)
DESIGN/CONTROL	5	20	5
MOBILIZATION	5	5	0
EXCAVATION	15 - 25	0	0
TRANSPORTATION/ DISPOSAL	200 - 275	0	0
HEALTH AND SAFETY	10	10	0
SUPERVISION	10	15 - 20	0
SITE RESTORATION	10	0	0
CONTRACTOR PROFIT	20 - 40	25 (4)	0
LABORATORY COSTS	15 - 25	12 - 15	15
REPORTING	10 - 15	12 - 15	15
TOTAL COSTS (5)	300 - 420	99 - 110	35

NOTES: (4) WELL DEVELOPERS, SAMPLERS.
(5) ALL COSTS ARE ESTIMATES AND ARE INTENDED TO PROVIDE RELATIVE COST COMPARISONS FOR REMEDIATION ALTERNATIVES. INFLATION FACTOR IS NOT CONSIDERED.