**<Warehouse Management System/WMS>**

# Database Design Document

**Version 1.0**

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## Introduction

This report seeks to describe the inventory management system being implemented at plant #111. Should the implementation of the inventory management system be successful this document can be used to develop similar DBMS at other plants within Lead Pharmaceuticals (LP). LP is a pharmaceutical company that manufactures biologic drugs. One of the key strategies to ensure continuous and efficient production while mitigating risk it to ensure the necessary materials needed for production are always readily available. This report will include process examples such as pH and DO probe standardization, autoclaving, BSC cleaning, clean in place (CIP), filter integrity tests (FIT) throughout, along with examples of materials used within these processes. Presently, there was no current DBMS or alternative system in place for inventory tracking at plant #111, all material order records, and material data are filed using paper documentation and manually tracked by manufacturing staff. With the implementation of the WMS, requests for material are submitted to vendors within the DBMS through a GUI. Once the Vendor fulfills the order request the plant is notified and staff update the WMS with the most current request information. Upon receiving the shipment via FedEx, USPS, or UPS the material data such as storage location and quantity are entered by qualified WMS users (typically warehouse personnel) and a material label printed with the material ID and barcode information which is then attached to the appropriate material. Once a material is used in the processes such as the ones previously described, the material label is scanned by the manufacturing staff into the appropriate manufacturing process and the material is considered used and is taken out of the available inventory. When more of a material is needed, a request is submitted and the staff member submitting the request signs off as the requestor and the process continues. This document describes the implementation of the WMS at plant #111, the primary audience includes management staff, warehouse staff, and manufacturing staff. Other departments such as finances and HR may request information from the DBMS but will be required to request this information to a DBMS administrator. Only qualified personnel such as supervisors and warehouse staff will have access to both submitted and receiving requests. Manufacturing staff can view and use materials but are not able to add or alter material data in any other way.

## Overview

The WMS will interact directly with an application server which in turn interacts with a database server that handles queries and maintenance through Oracle SQL. Users will primarily interact with the application server, which acts to manage external data being input and primarily coordinates data manipulations such as receival of material shipments, taking materials out of inventory by using them within a process, and submitting requests to vendors via a GUI. Inventory levels are monitored, and when inventory reaches a minimum threshold, the WMS electronically alerts warehouse staff. The main objective of this database is to accurately portray the available material data in real time, while protecting sensitive employee data contained within the database and maintaining security measures where applicable. The WMS also seeks to achieve storing large amounts of data that is easily and quickly accessible, while also maintaining a high level of data accuracy. This will aid in faster processing and lowers the possibility of process deviations due to low material inventories. The 2 primary dependencies of the WMS are the application server, as it is what is responsible for the primary data transactions previously described, which additionally occur frequently with a high traffic of users. The next dependency is the hardware hosting the server and staff’s access to these computers to perform necessary transactions. A .net coding framework will be used to create the necessary interfaces that communicate wit the server, this is important as there is no current framework in place. Overall, upon implementation of the WMS it is expected that there will be many improvements to processing time lost and fewer deviations can be expected, the WMS will also provide easier access to material cost tracing.

## Literature Review

A comparable DBMS was developed for a grocery business called At-Thoyyib, located in Parit Raja, Malaysia. The implementation of the Inventory Management System (IMS) was adapted at At-Thoyyib for reasons like why the Warehouse Management System is being implemented at plant #111. Prior to the inventory management system At-Thoyyib also used paper records for tracking inventory within the store. This led to greater margins of error and overall inefficient tracing of inventory, this was especially true for perishable items and frozen goods. The IMS was implemented in 5 phases: planning, analysis, design, implementation, and testing. The SDLC used in their project was the waterfall model, this aided in a well-defined planning and scheduling of the project and is especially beneficial as it is easier to explain to users. Comparable to the WMS, the initial design of the IMS was described using an ERD, and in addition a Decision Flow Diagram (DFD) was also developed. For the implementation stages, PHP and MySQL were used whereas in the project described in this technical report utilized Oracle SQL. The DBMS that was implemented consisted of several modules; module supplier, a module of goods, goods in and damaged, sales, employee module, a module leave application, approval module and leave the module report. The provider module allows either administrators or other employees to update provider information such as provider name, complete address, telephone number and email address. The design did account for security measures, before accessing any of the modules a login page is launched that requires users to enter their user ID and passwords and users are required to log off before exiting the system. Within the system there are also database administrators, who are the only employees allowed to access the employee module to add or update employee information. Once the modules were designed, the final phase testing was conducted in which each of the modules created were tested for functionality, all of which passed. Additionally, the IMS provided an easily navigable GUI that allowed employees to navigate through the system and required minimal training. The scope of the IMS project is like the WMS project, this DBMS only accounts for the one At-Thoyyib site. Accounting for expansion to additional sites it outside the scope of both projects (Julianna et al., 2018).

This review was useful because it demonstrated the necessity for a good SDLC, which forms the foundation for implementing a well-constructed DBMS. It also demonstrated a good basic design for how security is handled within the DBMS, and similar approaches were adapted for the WMS project. Finally, going forward with the WMS the GUI design seen on the user end should also be considered.

## Assumptions/Constraints/Risks

### Assumptions

This technical report assumes that the WMS is being placed as a new system, and there will be no impact to an existing system since one does not exist. Because there is no current system, it is assumed that new hardware will be supplied for implementing the system and that the WMS will operate on a Windows 11 OS, though the system will have the capabilities of running on Windows 10 and that the proper licenses are obtained to support the necessary software. It is also assumed that the WMS will be continuously improved upon and updated by LP to fit the needs at plant #111. Additionally, though usability was factored into the design of the database it is assumed that the WMS will be used by employees who have experience with a similar system or have received adequate training provided by LP.

### Constraints

One constraint of the database is that it only tracks materials in plant #111 that relate to manufacturing the biologic drug and are supplied by a vendor. The DBMS could be expanded to include materials used in the manufacturing process such as water for infusion (WFI), which is not supplied by a vendor but generated on site. Tracing of these additional materials would be useful in cost tracking but are currently not included in the database as they are not linked to an outside vendor. Additionally, materials can only be viewed and updated by one user at a time to ensure that there are no transaction overlaps. This could be remedied by addition of concurrency controls added later.

### Risks

Risks with the WMS include its overall capabilities, this DBMS is limited to 5 overreaching modules: staff, vendor, request, manufacturing, and materials. For the system to become more automated and require fewer manual entries (which themselves contain risk of errors upon data entry) more modules will need to be generated.

## Design Decisions

### Key Factors Influencing Design

There were several factors considered when making the design decisions. First the materials available such as hardware and software as well as the application server had to be considered prior to the actual WMS design. The biggest factor when considering resources was the capability of the system to handle a large volume of users and data for 24/7 plant operation, while also staying within LP’s budget. A Service Level Agreement (SLA) was also established from the administrator which was a factor included in the design. This agreement outlined that the system be available 24/7, recovery time should be no more than 1 hour in the event of a crash, and transaction response time should not exceed 3 seconds. Once the resources and SLA were considered, an ERD was constructed to display the key modules needed to form the database. The Staff module contains all employee information who may be a user in the database. The Vendor module contains the vendor description and contact information. The Manufacturing module contains the data for all previous, current, and future manufacturing processes that will use materials contained within the database. The Request module tracks previous and ongoing material requests and the staff and vendor associated with the request. Lastly, the Material module contains the material data such as description, quantity available and storage location as well as additional metadata. The final deliverable includes the ERD and final scripts.

### Functional Design Decisions

The primary functional design is dependent on the application server. The application server interacts with the input which is either manual entry from warehouse staff or through secure .csv or .text document uploads, the application server then parses and inputs the data into the SQL language which is the inserted and committed in the database. The application server also handles all updates or deletions of data in a similar fashion, and all output documents are either generated in a .pdf or. excel file. The user interacts with a GUI which is supported on Windows 11, the GUI as previously described is designed to be easy to use, but users should receive appropriate training prior to receiving access. When new data such as new staff, vendor, manufacturing process, request, or material is added into the database it is added sequentially and assigned a unique number. Each module contains different levels of sequential incrementing, so each unique ID is also different from other module IDs. These numbers are generated using triggers created in the SQL script. Additionally, 5 views and 20 queries were also supplied within the script to allow accessing heavily queried data faster and easier. The views that were developed primarily provide data that draws from more than one module, making searching much faster while also only displaying the necessary data.

### Database Management System Decisions

The initial design of for the DBMS was intended to be broad and malleable. Though the initial design is only to be used at plant #111, the possibility of DBMS expansion to other sites was discussed and is possible though with further development but not with the current design. It was intended that the DBMS be updated and made more efficient as the system is continuously used and more versions developed. The current database is Warehouse\_Management\_System version 1.0. The database was designed on Oracle 19c Enterprise Edition Release version 19.3.0.0 (Build MAIN 204.1703). This database was chosen for its functionality and reliability, and the developers already have a good understanding of the system. The necessary licenses were also within LP’s budget for the project.

### Security and Privacy Design Decisions

User’s will only be allowed access to the database upon successful completion of required training, the design of the raining will be outside the scope of this project. Only users with access level of ‘Supervisor’ within the Staff module will be allowed to access certain data such as the staff table which contains sensitive employee information. Additionally, for users to access the database they must first login to the system using an assigned user ID and password which is associated with their access level. Users may not share their login information with any other employees. The hardware providing access to the database is also kept in certain rooms where badge access is needed to gain entry. Data partitioning is also used throughout the database. Once the WMS is implemented a Secure Sockets Layer (SSL) will be implemented to protect the connections between the user and the server, this will be performed by a third-party vendor.

### Performance and Maintenance Design Decisions

* Due to the importance of accurate inventory data and anticipated heavy use of the database within the plant, LP requested additional recovery and backup maintenance be implemented in addition to what was recommended by developers. As such, rather than daily transaction backups, transaction log backups will occur every 12 hours to ensure daily material movements are not lost. Full DBMS backups will occur weekly on Mondays at 2pm. Additionally, differential backups will temporarily store the weekly data in between the full backups as additional precautions (GeeksforGeeks, 2022).
* To avoid concurrency issues, only one user may access each material and manufacturing process at a time. Error messages will be programmed to be displayed by the GUI when duplicate data is entered. Additionally, the DBMS was designed in a way that material data can only be entered when there are existing criteria aligning with the new material data such as an existing matching request and vendor.
* The SLA established with the administrator required that the system be available 24/7, recovery time could be no more than 1 hour in the event of a crash, and transaction response time should not exceed 3 seconds. Because the DBMS needs to be quickly recoverable, an on-call number of an IT specialist will be provided and easily accessible for 24/7 support.
* During periods where the database is being backup or recovery is being performed, the database will only be accessible by select employees for security purposes and to avoid possible loss of data. Because of this, though the backup periods for the database will be relatively short it is understood that the plant operates on a 24/7 schedule. Should there be a high production workload during periods where there is scheduled maintenance or during the weekly full backups, these backup and recovery periods will be allowed a 12-hour buffer period. To further clarify, the scheduled maintenance can be moved to either 12 hours before or after the scheduled maintenance time. The use of new or non-standard technology was considered as well, however, the addition of technologies such as videos and media seemed unnecessary for the primary reasons the WMS is being implemented. Should the database be expanded to include additional modules or to other plants, the topic of new technologies may be revisited.
* The database is expected to continue expanding as more materials are added and processes performed, because of this reorganization of data for better optimization and reduced data fragmentation is necessary. This will primarily be performed using Oracle’s Reorg Wizard to help with space utilization and with disorganized indexes (DCSoftware Inc., 2018). This will be performed during backup periods.
* Material data must be traceable and easily accessible for up to several years due to possible government agency audits or possible vendor material recalls that could affect the quality of LP’s drug product. Data will be archived automatically every 3 years based on data partitioned by year. As partitioned data reaches year 3, that data will move to storage on a solid-state drive (SSD) in the form of text-files, and the same partitioned data that was moved to the SSD will be automatically deleted in the database using SQL DELETE. Once every 6 months the SSD containing the archived data will be replaced and stored in a designated location.

## Statement of Work

1. **Overview/Executive Summary:**  
   Lead Pharmaceuticals (LP) is a pharmaceutical company that develops biologic drug products. To sell their products, they are required to be compliant with both the Food and Drug Administration (FDA) and the European Medical Agency (EMA), and as such they are held to stringent procedural standards for manufacturing their products. Many of the steps within their processing (i.e., sampling, pH adjustment, inoculations, vessel cleanings) must occur within certain time frames to remain compliant. Non-compliancy leads to deviations, and in severe cases, discarding of the drug product which costs the company large amounts of money. It is important that processing materials be always available and easily obtainable to avoid situations where processing is affected due to lack of materials.
   1. Executive Summary

A Warehouse Management System (WMS) database will be developed in LP’s primary plant #111 to track all materials within the facility, this will increase processing efficiency, accuracy, and ultimately compliance. The database will provide accurate data about material quantities and storage locations. It will allow traceability of total material cost to use for cost analysis of each procedure and provides information on expiration dates, another important detail for upholding compliance. Material numbers and associated barcodes will be assigned to each material, if new materials are acquired a unique material number will be generated and added into the database. If materials are no longer used, material numbers will be deleted from the database. This SOW will provide the additional outline of the objectives, timeline, scope, goals and deliverables, benefits, technology to be used, and an SQL usage and style guide for the proposed WMS database.

2. **Purpose and Objectives**:

2.1 Objectives of your database project

The WMS will be used to increase efficiency of material movement by tracking all materials throughout plant #111. This encompasses materials as they are received from vendors through when they are used in processing. The database will interact with a server that accepts data about material numbers and barcode information. It will track addition of materials by warehouse staff as deliveries are received as well as material consumptions as they are used by technicians. It will house material’s current locations, which is updated by qualified staff as materials are moved. Objectives include accurate storage of large amounts of data such as material quantities, storage locations, and transaction history (addition and consumption of materials) to ensure accurate representation of material availability. This makes sure material stocks do not dip below a specified threshold. WMS will also assist with tracking overall cost of production. It will store material information securely, only certain personal can access information on material cost and submit material requests to vendors, and certain hazardous materials can only be handled by appropriately trained staff. Once the database is implemented it is recommended that additional organizational methods such as 5S be implemented to improve efficiency of material stocking and requests, this is not within the scope of this project.

1. Project Timeline

It is important to stick to the scheduled timeline of the database to costs of development do not exceed what was originally expected:

* SOW submission on 09/13/2022.
* Developed Requirements Definition Document and Entity Relationship Diagram (ERD) to provide business rules and design outline of the database by 09/27/2022.
* Create physical database objects that implement the logical objects, using SQL Data Definition Language (DDL) by 10/11/2022.
* Complete definition of database schema by entering data into tables and perform query testing by 11/01/2022.
* Submission of the WMS Technical Report by 11/08/2022.

1. Project Scope

The purpose of this database project it to provide the expectations and business rules, and a visual outline represented by an ERD. It will provide SQL scripts using DDL, along with queries to ensure successful object creation. It will create a SQL script using DML along with database testing to check for functionality. The database is to be implemented at this specific plant (#111). This material database may work in conjunction with other third-party systems, the setup and construction of those relationships will not be within the scope of this project. Other plants within the company are outside the scope of this project. A data recovery strategy and general software maintenance for the WMS once the database is implemented is outside the scope of this project but should be considered within the design. Implementation of security measures between the users and the database is also outside of the scope of this project.

* + - 1. Work within the scope of the project
* The creation of initial business rules and outline of the WMS.
* Developed SQL scripts using DDL and DML.
* Final implementation of WMS at plant #111.
  + - 1. Work outside the scope of the project
* Setup and integration of relationships between the WMS and other third-party systems (ie MES, Sharepoint).
* Extending management of materials to other plants within the company, this WMS will be kept solely in house.
* Data recovery strategy and software maintenance strategies are not within the scope of this project but should be considered.
* Addition of security measures for the client-server access is recommended but not included within this project.

1. **Database Goals, Expectations, and Deliverables**

Database goals and expectations include accurate tracking of materials within the warehouse, as they are ordered and received from vendors until they are used within processing. Specifically, it will track materials received from vendors, receival of materials to the warehouse, movement of materials to requested rooms, and then consumption of material for processing. Deliverables include this SOW, a developed requirements definition document, an ERD diagram, SQL DDL and DML scripts, and the database.

1. **Database Benefits**

The WMS will ultimately provide more efficient tracking and control of materials within plant #111. Within the pharmaceutical industry special procedures (SOPs, PBRs) are followed step-by-step to ensure products are compliant, when materials are out of stock or not in their proper locations this can slow or halt processing and ultimately cost the plant money. Implementation of the WMS will help to avoid these instances by accurately tracking location and quantities of materials throughout the entire plant, and by ensuring minimum quantities of materials are continuously available. Additionally, the WMS provides a centralized location for analyzing total cost of materials and is a valuable resource for cost analysis by the financial department. The warehouse management system also aids in tracking material expiration dates, this is critical in pharmaceuticals as using expired materials can result in a deviation and may lead to product non-compliance.

1. **Hardware and Software**
   1. Object Hardware/Software

Server side-technologies are accessed by the client through UMGCs Virtual Desktop Access (VDA), they are run on an Intel(R) Xeon(R) Platinum 8370C CPU @ 2.80GHz processor that is a 64-bit operating system, x64-based processor. It is run on Windows 11 Pro version 21H2.

Client-side technologies will be accessed using Microsoft Edge Version 105.0.1343.33 (Official Build) 64-bit, run on Windows 10 Home version 21H2.

* 1. Diagramming Tool Identified

ER-Assistant version 2.10 running on Windows 11 Pro will be the diagramming tool, and crow’s feet notation will be used.

* 1. Database

Oracle SQL Developer version 19.3.0.0 run through UMGC’s VDA on Windows 11 Pro will be used to develop the database.

* 1. Office Productivity Tools

Microsoft Office run on Windows 10 Home version 21H2.

* 1. Access Method Identified

Clients will use using Microsoft Edge Version 105.0.1343.33 (Official Build) 64-bit, run on Windows 10 Home version 21H2 to access the WMS in the server. This should be a secure connection due to the nature of the data contained within the WMS, only trained employees within the plant should be able to access the WMS. To increase security measures, it is recommended that a Secure Sockets Layer (SSL) be implemented to protect the connections between the client and the server (Microsoft, 2021). This would be done by a third party and is outside the scope of this project.

1. **SQL Usage and Style Guide**

It is important to use the SQL Usage and Style Guide throughout the development of this project, it beneficial for maintaining consistency throughout the database and will aid team members working on the databases development.

*The following Naming Conventions and SQL Statement Structure and Readability style guides were adapted from Ben Brumm and can be retrieved from* [*https://www.databasestar.com/sql-best-practices/*](https://www.databasestar.com/sql-best-practices/)

* 1. Naming Conventions
* Avoid using spaces I object names
* Avoid using quotations within object names
* Avoid square brackets around object names
* Use underscores instead of camel case
* Avoid prefixes for object names
* Avoid reserved words for object names (i.e User, Order, Upper, etc.)
* Use singular names rather than plural names
* Don’t name columns the same as the table
* Name joining tables based on what they represent.
* Specify names of constraints instead of the default
* Consider using prefixes on constraint names
  1. SQL Statement Structure for Readability and Script Format
* Use meaningful table aliases as your query grows
* Use AS for column aliases
* Use consistent case for keywords
* Keywords should start a new line
* Columns in SELECT clause should be in their own lines.
* Commas for columns should go at the end of a line
* Add a space before and after =
* Treat tables in joins as siblings and don’t indent them
* Put multiple join conditions on separate lines
* Indent subqueries
* Finish each statement with a semicolon

*The following Comment Usage style guide was adapted from Rob Parker and can be retrieved from https://about.gitlab.com/handbook/business-technology/data-team/platform/sql-style-guide/*

* 1. Comment Usage
* When making single line comments in a model use the – syntax
* When making multi-line comments in a model use the /\*\*/ syntax
* Respect the character line limit when making comments.
* Utilize the dbt model documentation when it is available
* Calculations made in SQL should have a brief description of what’s going on if available.
* Instead of leaving TODO comments, create new issues for improvement.
  1. DDL/DML

Physical database objects: tables, columns, keys, and indexes will all be developed once the ERD and design model are approved, this will be done using SQL Data Definition Language (DDL). All objects within the database will have drop statements. DDL Create statements will be used for all tables and associated objects, for example creating tables for the warehouse, the warehouse team, the manufacturing employees, the material restocking request transaction, and consumption of the materials to the product. Once the tables are created, the indexes can be added to necessary columns to speed up queries. DDL will then be used to add additional objects such as sequences, views, and triggers which will facilitate data entries and triggers.

Once the database schema is well defined, data can be entered into the tables using data manipulation language (DML) to create SQL insert statements. This will populate each table with sample data, for example the warehouse table might have a statement to insert the material\_ID, quantity, and storage\_room into the table. SQL select statements will then be used to query the tables.

## Requirements Analysis

This document represents the Requirements Definition Document for the Warehouse Management Database (WMS) being implemented at plant #111 at Lead Pharmaceuticals (LP) and attempts to describe the ERD diagram located in Appendix A and described in section 8 of this technical report.

**Entities and Attributes**

**Entity Name**: STAFF

**Entity Description**: This table describes information about all employees who works within the warehouse and manufacturing departments. Some may have special Warehouse Management System (WMS) access which is described by the ACCESS\_LEVEL attribute, it is up to DBMS Administrators to manage the employee data within this entity.

**Main attributes of STAFF**:

PK: STAFF\_ID

FK: None

Parent Entity: None

Attribute Name: STAFF\_ID (PK)

Attribute Description: unique ID number specific to each employee, used for accessing the database and tracing who handles materials.

Attribute Name: LAST\_NAME

Attribute Description: staff’s last name.

Attribute Name: FIRST\_NAME

Attribute Description: staff’s first name.

Attribute Name: PHONE

Attribute Description: phone number of staff member and primary means of contact.

Attribute Name: DOB

Attribute Description: date of birth.

Attribute Name: SSN

Attribute Description: social security number

Attribute Name: ACCESS\_LEVEL

Attribute Description: The level of access the staff member has to data within the database, such as access to the REQUEST entity.

**Entity Name**: VENDOR

**Entity Description**: This entity describes all information regarding the vendor/supplier who manufactures the materials, including primary contact information. It is up to DBMS Administrators to manage the data within this entity.

**Main attributes of VENDOR**:

PK: VENDOR\_ID

FK: None

Parent Entity: None

Attribute Name: VENDOR\_ID (PK)

Attribute Description: unique ID number associated with each vendor who supplies materials to the plant.

Attribute Name: VENDOR\_PHONE

Attribute Description: the vendors phone number

Attribute Name: VENDOR\_EMAIL

Attribute Description: the vendors email address

Attribute Name: VENDOR\_NAME

Attribute Description: the name of the vendor, another identifier

Attribute Name: VENDOR\_FAX

Attribute Description: the vendors fax number

**Entity Name**: MANUFACTURING

**Entity Description**: This entity describes each manufacturing process that materials are used in and is very useful for material traceability. When materials are consumed to a manufacturing process they are no longer available for use within the WMS, it is up to primary users and DBMS administrators to ensure accurate tracing of materials.

**Main attributes of MANUFACTURING**:

PK: PROCESS\_NUMBER

FK: MANUFACTURING\_STAFF (FK\_STAFF\_STAFF\_ID)

Parent Entity: STAFF

Attribute Name: PROCESS\_NUMBER (PK)

Attribute Description: Unique ID number of manufacturing good the material is being used to manufacture.

Attribute Name: PROCESS\_DESCRIPTION

Attribute Description: Description or name of process in the form of characters, allows for easier database user process identification.

Attribute Name: MANUFACTURING\_STAFF (FK)

Attribute Description: unique ID number specific to each employee, used for accessing the database and tracing who handles materials.

Attribute Name: DATE\_USED

Attribute Description: Date material was used for processing. Date cannot be past date listed in the EXPIRATION\_DATE attribute in the MATERIAL entity.

Attribute Name: PROCESS\_STATUS

Attribute Description: whether process is pending or complete, can help approximate upcoming processes that may require materials

Attribute Name: QUANTITY\_USED

Attribute Description: Number of materials used for the process.

Attribute Name: WASTED\_MATERIALS

Attribute Description: Number of material that were wasted rather then used in the manufacturing process (i.e., material was damaged/defective), if any.

**Entity Name**: REQUEST

**Entity Description**: This entity contains information for material requests and current orders for more materials, this prevents low inventories of materials and aids in diminishing duplicate requests that lead to too many materials.

**Main attributes of REQUEST**:

PK: REQUEST\_ID and VENDOR\_ID\_FK

FK: STAFF\_ID (FK\_STAFF\_pk\_STAFF\_ID), VENDOR\_ID (FK\_VENDOR\_pk\_VENDOR\_ID)

Parent Entity: STAFF and VENDOR

Attribute Name: REQUEST\_ID (PK)

Attribute Description: unique ID number generated for the request.

Attribute Name: REQUESTING\_STAFF (FK)

Attribute Description: unique ID number specific to each employee, allows traceability of which staff submitted a request.

Attribute Name: VENDOR\_ID\_FK (PK)(FK)

Attribute Description: ID of the vendor the request is being submitted to.

Attribute Name: REQUEST\_QUANTITY (PK)

Attribute Description: quantity of the material being requested.

Attribute Name: DATE\_NEEDED

Attribute Description: the date a material is needed by for processing.

Attribute Name: COMPLETION\_STATUS

Attribute Description: the status of whether the request is pending or complete.

Attribute Name: DATE\_REQUESTED

Attribute Description: the date the material is needed by for processing.

Attribute Name: NOTE

Attribute Description: this is a text description providing additional information regarding the request if applicable (i.e., delivery instruction, shipment updates provided by the vendor, etc.)

**Entity Name**: MATERIAL

**Entity Description**: This entity provides data for all materials within plant #111, such as where materials are currently located as well as quantity available.

**Main attributes of MATERIAL:**

PK: MATERIAL\_ID and REQUEST\_ID\_FK

FK: PROCESS\_NUMBER\_FK (FK\_MANUFACTURING\_pk\_PROCESS\_NUMBER), REQUEST\_ID\_FK (FK\_REQUEST\_pk\_REQUEST\_ID), and VENDOR\_ID (FK\_VENDOR\_pk\_VENDOR\_ID)

Parent Entity: REQUEST and MANUFACTURING

Attribute Name: MATERIAL\_ID (PK)

Attribute Description: unique ID number generated for each material type.

Attribute Name: REQUEST\_ID\_FK (PK)(FK)

Attribute Description: unique ID number generated for the request.

Attribute Name: PROCESS\_NUMBER\_FK (FK)

Attribute Description: the process the material is used in.

Attribute Name: VENDOR\_ID\_REQUEST\_FK (FK)

Attribute Description: unique ID number associated with each vendor who supplies materials to the plant. It should be noted that rather than generate a redundant relationship with the VENDOR table, the vendor\_id FK will be obtained from the REQUEST table.

Attribute Name: EXPIRATION\_DATE

Attribute Description: date the material expires, if applicable. Value cannot be a past date.

Attribute Name: HAZARD\_LEVEL

Attribute Description: some materials are considered hazardous and should be handled and stored in a certain way, hazard level indicates what kind of hazard a material is, if applicable.

Attribute Name: MATERIAL\_NAME

Attribute Description: Description and name of material, provides easier material identification for database users.

Attribute Name: QUANTITY\_AVAILABLE

Attribute Description: number of total materials available throughout plant #111. There should be a minimum required quantity.

Attribute Name: STORAGE\_LOCATION

Attribute Description: location of where material is currently stored within plant #111.

Attribute Name: PRICE

Attribute Description: cost of each unit of the material.

**Relationships**

Relationship: “fulfills” between VENDOR and REQUEST

Cardinality: 1:M between VENDOR and REQUEST

Business rule: Both REQUEST and VENDOR are mandatory. A vendor will not fulfill a request unless a request is present, and a request cannot be fulfilled unless there is a vendor to fulfill it. A vendor may fulfill zero, one, or many requests, and each request is fulfilled by only one vendor.

Relationship: “submits” between STAFF and REQUEST

Cardinality: 1:M between STAFF and REQUEST

Business rule: STAFF is mandatory, and REQUEST is optional. A request cannot be submitted unless a staff member is present to submit it. A staff member may or may not submit a request. A staff member can submit zero, one, or many requests, each request is made by only one staff member.

Relationship: “conducts” between STAFF and MANUFACTURING

Cardinality: 1:M between STAFF and MANUFACTURING

Business rule: STAFF is mandatory, and MANUFACTURING is optional. A process can only be done is a staff is available to conduct it and a staff member may or may not conduct a process. A staff member can perform zero, one, or many processes. A process is only performed by one staff.

Relationship: “uses” between MATERIAL and MANUFACTURING

Cardinality: 1:M between MANUFACTURING and MATERIAL

Business rule: MATERIAL is optional while MANUFACTURING is mandatory. A process can be performed without a material, a material must be used in a process. A process can use zero, one, or many materials, each material is used in only one process.

Relationship: “submits” between REQUEST and MATERIAL

Cardinality: 1:M between REQUEST and MATERIAL

Business rule: Both REQUEST and MATERIAL are mandatory. A material must be requested for there to be materials, and a request cannot be made unless there is a material to be requested. A request can be made for one or many materials. Each material is associated with only one request.

**Assumptions and Special considerations:**

Due to the nature of the information being stored within the WMS and the critical nature of data integrity and accuracy, it is assumed that employees listed within the STAFF entity will have the appropriate training and access levels assigned to them. It is up to the plant #111’s discretion on how each staff member will be classified within the database, and what the tiers within the access level attribute will be. Special and careful consideration should be taken when designing the training requirements for staff, for example only qualified staff should only be allowed to request materials from a vendor to avoid incorrect material quantities.

The purpose of this database is to prevent material shortages by maintaining the necessary material quantities. A minimum required quantity will be established for each material to aid in achieving this goal, and to prevent running too low on a materials inventory. It is assumed the plant will provide these minimums, which may change based on the processing requirements within the plant. It is also assumed that this minimum will not be included within the WMS. Considerations should be taken for what procedure should occur once a minimum quantity is reached and how this will be tracked, such as implementation of an AGILE 5S system.

The WMS database should additionally *accurately* track material quantities. It is assumed that the attribute QUANTITY\_AVAILABLE within the MATERIAL entity will be a calculated value; when a value in the REQUEST entity has a COMPLETION\_STATUS of complete, the quantity in the QUANTITY\_REQUESTED attribute will be added to the QUANTITY\_AVAILABLE attribute. Inversely, in the MANUFACTURING table the values in the WASED\_MATERIALS and QUANTITY\_USED for each entry will be subtracted from the QUANTITY\_AVAILABLE attribute for each material.

## Detailed Database Design

### Data Software Objects and Resultant Data Structures

### The WMS does not contain any data software objects or resultant data structures. The WMS will operate primarily electronically, new data being manually inserted by DBMS administrators. Occasionally, supporting departments such as HR or the Finance department may request data from the WMS which will be generated as an excel or .pdf file if a physical copy is requested, or as a GUI.

### Database Management System Files

* There are 5 primary schemas constructed in WMS database: STAFF, VENDOR, MANUFACTURING, REQUEST and MATERIAL. See Figure 1 of the ERD in Appendix A.
* Multiple indexes were generated for all FK’s; on MANUFACTURING index MANUFACTURING\_STAFF\_FK was created for the MANUFACTURING\_STAFF attribute. On the REQUEST entity the index REQUEST\_VENDOR\_FK was created for the VENDOR\_ID\_FK and the index REQUEST\_STAFF\_FK was created for the REQUESTING\_STAFF foreign key. On the MATERIAL entity the index MATERIAL\_REQUEST\_FK was created for both the REQUEST\_ID\_FK and VENDOR\_ID\_REQUEST\_FK and the index MATERIAL\_MANUFACTURING\_FK was created for the PROCESS\_NUMBER\_FK.

To support queries that are anticipated to be frequently used, additional indexes were created for all natural keys and frequently used columns. On the entity VENDOR, indexes were created for the VENDOR\_NAME and VENDOR\_PHONE attributes. On the STAFF entity, indexes were created on LAST\_NAME and FIRST\_NAME. On the MANUFACTURING entity, indexes for QUANTITY\_USED were created. On the REQUEST entity, indexes were created for REQUEST\_QUANTITY, DATE\_REQUESTED, and DATE\_NEEDED. Lastly, on the MATERIAL entity, indexes for EXPIRATION\_DATE and HAZARD\_LEVEL were created.

* For ease of readability and organization of data, the SQL file is grouped by the 5 schemas previously described, with additional comments provided for clarification. The DDL makes up the first half of the file, and the DML makes up the second half of the file. Within each half the file is organized by 5 schemas. The 20 additional queries are included at the end of the file.
* The text file containing the consolidated DDL, DML, and 20 queries makes up 23 pages or a 34KB text file, this includes free space between comments and statements and overall accounts for 804 lines in Oracle SQL Developer. Elimination of free space was considered, however, the additional file size due to the added free space was deemed to be allowable as the free space allows for a more easily readable file which is helpful for future troubleshooting and updates to the DBMS.
* The WMS database will be updated daily because plant#111 operates 24/7 due to the nature of the biologic manufacturing process, processes will be performed frequently and throughout the day. This means materials will be ordered, supplied, moved, used, and viewed frequently. The generation of physical prints and manual uploads to the system are not as frequently anticipated, this will primarily be performed when other supporting departments (i.e., HR, finance, etc.) request this data. These departments operate on a standard daytime schedule.

**DDL Source Code**

/\*drop statements list\*/

DROP TABLE STAFF CASCADE CONSTRAINTS;

DROP TABLE VENDOR CASCADE CONSTRAINTS;

DROP TABLE MANUFACTURING CASCADE CONSTRAINTS;

DROP TABLE REQUEST CASCADE CONSTRAINTS;

DROP TABLE MATERIAL CASCADE CONSTRAINTS;

DROP SEQUENCE STAFF\_ID\_SEQ;

DROP SEQUENCE VENDOR\_ID\_SEQ;

DROP SEQUENCE PROCESS\_NUMBER\_SEQ;

DROP SEQUENCE REQUEST\_ID\_SEQ;

DROP SEQUENCE MATERIAL\_ID\_SEQ;

CREATE TABLE STAFF(

STAFF\_ID NUMERIC(10) NOT NULL PRIMARY KEY,

LAST\_NAME VARCHAR(50) NOT NULL,

FIRST\_NAME VARCHAR(50) NOT NULL,

PHONE NUMERIC(25) NOT NULL,

DOB DATE,

SSN NUMERIC(9) NOT NULL,

ACCESS\_LEVEL VARCHAR(15) NOT NULL

);

CREATE TABLE VENDOR(

VENDOR\_ID NUMERIC(10) NOT NULL PRIMARY KEY,

VENDOR\_EMAIL VARCHAR(100) NOT NULL,

VENDOR\_PHONE NUMERIC(11) NOT NULL,

VENDOR\_NAME VARCHAR(50) NOT NULL,

VENDOR\_FAX NUMERIC(20)

);

/\*MANUFACTURING table creation\*/

CREATE TABLE MANUFACTURING(

PROCESS\_NUMBER NUMERIC(10) NOT NULL PRIMARY KEY,

PROCESS\_DESCRIPTION VARCHAR(30),

MANUFACTURING\_STAFF NUMERIC(10) NOT NULL,

DATE\_USED DATE,

/\*

For completion\_status column, boolean statement is indicated

by a number data type because Oracle SQL developer does not allow boolean

statements. 1= True 0=False

\*/

PROCESS\_STATUS NUMERIC(1),

QUANTITY\_USED NUMERIC(5) NOT NULL,

WASTED\_MATERIALS NUMERIC(20),

/\*process table constraints and indexes

/\*FK naming convention

[child entity where fk column is located]\_[parent entity]\_FK\*/

CONSTRAINT MANUFACTURING\_STAFF\_FK FOREIGN KEY (MANUFACTURING\_STAFF)

REFERENCES STAFF(STAFF\_ID)

);

CREATE TABLE REQUEST(

REQUEST\_ID NUMERIC(10) NOT NULL,

VENDOR\_ID\_FK NUMERIC(10) NOT NULL,

REQUESTING\_STAFF NUMERIC(10) NOT NULL,

REQUEST\_QUANTITY NUMERIC(30) NOT NULL,

DATE\_NEEDED DATE,

/\*

For completion\_status column, boolean statement is indicated

by a number data type because Oracle SQL developer does not allow boolean

statements. 1= True 0=False

\*/

COMPLETION\_STATUS NUMERIC(1) NOT NULL,

DATE\_REQUESTED DATE NOT NULL,

NOTE VARCHAR(500),

/\*

request table constraints and indexes

\*/

CONSTRAINT PK\_REQUEST PRIMARY KEY (REQUEST\_ID, VENDOR\_ID\_FK),

CONSTRAINT REQUEST\_VENDOR\_FK FOREIGN KEY(VENDOR\_ID\_FK)

REFERENCES VENDOR(VENDOR\_ID),

CONSTRAINT REQUEST\_STAFF\_FK FOREIGN KEY(REQUESTING\_STAFF)

REFERENCES STAFF(STAFF\_ID)

);

CREATE TABLE MATERIAL(

MATERIAL\_ID NUMERIC(10) NOT NULL,

REQUEST\_ID\_FK NUMERIC(10) NOT NULL,

PROCESS\_NUMBER\_FK NUMERIC(10),

VENDOR\_ID\_REQUEST\_FK NUMERIC(10) NOT NULL,

EXPIRATION\_DATE DATE,

HAZARD\_LEVEL VARCHAR(20),

MATERIAL\_NAME VARCHAR(75) NOT NULL,

QUANTITY\_AVAILABLE NUMERIC(30) NOT NULL,

STORAGE\_LOCATION VARCHAR(20) NOT NULL,

PRICE NUMERIC(5) NOT NULL,

/\*

material table constraints and indexes

\*/

CONSTRAINT PK\_MATERIAL PRIMARY KEY(MATERIAL\_ID, REQUEST\_ID\_FK),

CONSTRAINT MATERIAL\_REQUEST\_FK FOREIGN KEY(REQUEST\_ID\_FK, VENDOR\_ID\_REQUEST\_FK)

REFERENCES REQUEST(REQUEST\_ID, VENDOR\_ID\_FK),

CONSTRAINT MATERIAL\_MANUFACTURING\_FK FOREIGN KEY(PROCESS\_NUMBER\_FK)

REFERENCES MANUFACTURING(PROCESS\_NUMBER)

);

/\*INDEXES FOR FOREIGN KEYS\*/

CREATE INDEX MANUFACTURING\_STAFF\_FK ON MANUFACTURING(MANUFACTURING\_STAFF);

CREATE INDEX REQUEST\_VENDOR\_FK ON REQUEST(VENDOR\_ID\_FK);

CREATE INDEX REQUEST\_STAFF\_FK ON REQUEST(REQUESTING\_STAFF);

CREATE INDEX MATERIAL\_REQUEST\_FK ON MATERIAL(REQUEST\_ID\_FK,

VENDOR\_ID\_REQUEST\_FK);

CREATE INDEX MATERIAL\_MANUFACTURING\_FK ON MATERIAL(PROCESS\_NUMBER\_FK);

/\*INDEXES FOR NATURAL KEYS AND FREQUENTLY USED COLUMNS\*/

--VENDOR name (natural key) and phone number

CREATE UNIQUE INDEX VENDOR\_NAME\_UX ON VENDOR(VENDOR\_NAME);

CREATE INDEX VENDOR\_PHONE\_UX ON VENDOR(VENDOR\_PHONE);

--STAFF FIRST AND LAST NAME (a frequently used identifier)

CREATE INDEX STAFF\_LAST\_NAME\_UX ON STAFF(LAST\_NAME);

CREATE INDEX STAFF\_FIRST\_NAME\_US ON STAFF(FIRST\_NAME);

--QUANTITY USED (useful for tracing where materials end up)

CREATE INDEX MANUFACTURING\_QUANTITY\_USED\_UX ON

MANUFACTURING(QUANTITY\_USED);

/\*REQUEST QUANTITY, DATE REQUESTED AND DATE NEEDED (frequently used data for

tracking submitted and needed requests

useful info for avoiding

too high/low inventory or duplicate requests\*/

CREATE INDEX REQUEST\_QUANTITY\_UX ON REQUEST(REQUEST\_QUANTITY);

CREATE INDEX REQUEST\_DATE\_REQUESTED\_UX ON REQUEST(DATE\_REQUESTED);

CREATE INDEX REQUEST\_DATE\_NEEDED\_UX ON REQUEST (DATE\_NEEDED);

/\*MATERIAL EXPIRATION DATE AND HAZARD LEVEL (these are frequently looked up

by operators for routine processing)\*/

CREATE INDEX MATERIAL\_EXPIRATION\_DATE\_UX ON MATERIAL(EXPIRATION\_DATE);

CREATE INDEX MATERIAL\_HAZARD\_LEVEL\_UX ON MATERIAL(HAZARD\_LEVEL);

/\*alter tables to include audit columns for tracing table updates and changes\*/

--STAFF

ALTER TABLE STAFF ADD

(CREATED\_BY VARCHAR2(30),

DATE\_CREATED DATE,

MODIFIED\_BY VARCHAR2(30),

DATE\_MODIFIED DATE);

--VENDOR

ALTER TABLE VENDOR ADD

(CREATED\_BY VARCHAR2(30),

DATE\_CREATED DATE,

MODIFIED\_BY VARCHAR2(30),

DATE\_MODIFIED DATE);

--MANUFACTURING

ALTER TABLE MANUFACTURING ADD

(CREATED\_BY VARCHAR2(30),

DATE\_CREATED DATE,

MODIFIED\_BY VARCHAR2(30),

DATE\_MODIFIED DATE);

--REQUEST

ALTER TABLE REQUEST ADD

(CREATED\_BY VARCHAR2(30),

DATE\_CREATED DATE,

MODIFIED\_BY VARCHAR2(30),

DATE\_MODIFIED DATE);

--MATERIAL

ALTER TABLE MATERIAL ADD

(CREATED\_BY VARCHAR2(30),

DATE\_CREATED DATE,

MODIFIED\_BY VARCHAR2(30),

DATE\_MODIFIED DATE);

/\*

Views

Format: VW\_{table\_name or description}

/\*

staff view business rule: this view contains frequently used info

needed for identifying employees within the WMS. Data such as DOB and SSN

are contained within the STAFF table. Because of this sensitive data

not all users will have access to the STAFF table to ensure employee privacy

rights are maintained. The VW\_STAFF view provides the staff full name and

contact data which may be required for manufacturing without displaying

sensitive employee information.

\*/

CREATE OR REPLACE VIEW VW\_STAFF AS

SELECT STAFF\_ID, FIRST\_NAME, LAST\_NAME, PHONE FROM STAFF;

/\*vendor view business rule: this view displays all of the information

within the vendor table except for the audit columns. This view will

primarily be used to obtaining the contact information of Vendors should

they need to be contacted. \*/

CREATE OR REPLACE VIEW VW\_VENDOR AS

SELECT VENDOR\_ID, VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_EMAIL, VENDOR\_FAX

FROM VENDOR;

/\*

request view business rule: this view is used for displaying the

material information associated with each created request.

Just viewing the REQUEST table alone does not provide this information,

this view is useful for looking up how many of a certain material was

requested and when, and whether the request has been completed.

This can be useful for tracing pending requests or deciding if another request

needs to be made to a vendor.

\*/

CREATE OR REPLACE VIEW VW\_REQUEST AS

SELECT REQUEST.REQUEST\_ID, REQUEST.DATE\_REQUESTED, REQUEST.VENDOR\_ID\_FK,

REQUEST.REQUEST\_QUANTITY, REQUEST.COMPLETION\_STATUS, MATERIAL.MATERIAL\_ID,

MATERIAL.MATERIAL\_NAME FROM REQUEST, MATERIAL WHERE

REQUEST.REQUEST\_ID = MATERIAL.REQUEST\_ID\_FK ORDER BY REQUEST.REQUEST\_ID;

/\*

manufacturing view business rules: this view is used for viewing what

materials were used within each manufacturing process. Just viewing the

MANUFACTURING table alone does not provide this information. This view

allows the manufacturing schedulers and warehouse department to trend

the use of each material as it relates to each process and supply materials

accordingly.

\*/

CREATE OR REPLACE VIEW VW\_MANUFACTURING AS

SELECT MANUFACTURING.PROCESS\_NUMBER, PROCESS\_DESCRIPTION, MANUFACTURING.PROCESS\_STATUS,

MANUFACTURING.DATE\_USED, MANUFACTURING.QUANTITY\_USED, MATERIAL.MATERIAL\_ID,

MATERIAL.MATERIAL\_NAME FROM MANUFACTURING, MATERIAL WHERE

MANUFACTURING.PROCESS\_NUMBER = MATERIAL.PROCESS\_NUMBER\_FK;

/\*material view business rule: this view includes the most used columns

needed for processing and tracing materials such as;

material id, expiration date, hazard level, quantity available, and

storage location. Columns with supplemental data and

and audit columns are not included.

This view is primarily useful for manufacturing staff who need

to know more information about a material as it relates to

manufacturing.\*/

CREATE OR REPLACE VIEW VW\_MATERIAL AS SELECT MATERIAL\_ID, MATERIAL\_NAME,

EXPIRATION\_DATE, HAZARD\_LEVEL, QUANTITY\_AVAILABLE, STORAGE\_LOCATION

FROM MATERIAL;

/\*sequence statements\*/

--sequence for STAFF table

CREATE SEQUENCE STAFF\_ID\_SEQ

INCREMENT BY 3

START WITH 230

NOMAXVALUE

MINVALUE 1

NOCACHE;

--sequence for VENDOR\_ID

CREATE SEQUENCE VENDOR\_ID\_SEQ

INCREMENT BY 15

START WITH 100

NOMAXVALUE

MINVALUE 1

NOCACHE;

--sequence for PROCESS\_NUMBER

CREATE SEQUENCE PROCESS\_NUMBER\_SEQ

INCREMENT BY 20

START WITH 100

NOMAXVALUE

MINVALUE 1

NOCACHE;

--sequence for REQUEST\_ID

CREATE SEQUENCE REQUEST\_ID\_SEQ

INCREMENT BY 3

START WITH 500

NOMAXVALUE

MINVALUE 1

NOCACHE;

--sequence for MATERIAL\_ID

CREATE SEQUENCE MATERIAL\_ID\_SEQ

INCREMENT BY 20

START WITH 1500

NOMAXVALUE

MINVALUE 1

NOCACHE;

/\*create triggers to populate the surrogate keys and audit columns\*/

/\*

Staff\_ID and Staff table audit columns trigger, business rule: each staff

member has a unique number assigned to them in case employees

share the same name, additional audit columns are automatically populated in

this trigger to trace any changes made to the data within the table.

\*/

CREATE OR REPLACE TRIGGER STAFF\_ID\_SEQ

BEFORE INSERT OR UPDATE ON STAFF FOR EACH ROW

BEGIN

IF :NEW.STAFF\_ID IS NULL THEN

:NEW.STAFF\_ID :=STAFF\_ID\_SEQ.NEXTVAL;

END IF;

IF INSERTING THEN

IF :NEW.CREATED\_BY IS NULL THEN :NEW.CREATED\_BY := USER; END IF;

IF :NEW.DATE\_CREATED IS NULL THEN :NEW.DATE\_CREATED := SYSDATE; END IF;

END IF;

IF INSERTING OR UPDATING THEN

IF :NEW.MODIFIED\_BY IS NULL THEN :NEW.MODIFIED\_BY := USER; END IF;

IF :NEW.DATE\_MODIFIED IS NULL THEN :NEW.DATE\_MODIFIED :=SYSDATE; END IF;

END IF;

END;

/

-- Vendor\_ID and vendor table audit columns trigger

/\*

VENDOR\_ID and VENDOR table audit columns trigger, business rule: each vendor

has a unique number assigned to them as an identifier.

This is to more easily identify which vendor supplies which material, as

different vendors may supply similar materials. Additionally, when shortages

occur materials may need to be obtained from different vendors. These ID helps

identify the material/vendor relationship.

Additional audit columns are automatically populated in

this trigger to trace any changes made to the data within the table.

\*/

CREATE OR REPLACE TRIGGER VENDOR\_ID\_SEQ

BEFORE INSERT OR UPDATE ON VENDOR FOR EACH ROW

BEGIN

IF :NEW.VENDOR\_ID IS NULL THEN

:NEW.VENDOR\_ID :=VENDOR\_ID\_SEQ.NEXTVAL;

END IF;

IF INSERTING THEN

IF :NEW.CREATED\_BY IS NULL THEN :NEW.CREATED\_BY := USER; END IF;

IF :NEW.DATE\_CREATED IS NULL THEN :NEW.DATE\_CREATED := SYSDATE; END IF;

END IF;

IF INSERTING OR UPDATING THEN

IF :NEW.MODIFIED\_BY IS NULL THEN :NEW.MODIFIED\_BY := USER; END IF;

IF :NEW.DATE\_MODIFIED IS NULL THEN :NEW.DATE\_MODIFIED :=SYSDATE; END IF;

END IF;

END;

/

-- PROCESS\_NUMBER sequence and manufacturing table audit columns trigger

/\*

PROCESS\_NUMBER and MANUFACTURING table audit columns trigger, business rule:

each manufacturing process has a unique number assigned to it.

This aids in traceability of each material used to manufacture the

pharmaceutical product if a product is found to have defects or an

investigation is occurring this unique identifier provides a quick and easy

option for searching the process data.

Additional audit columns are automatically populated in this trigger

to trace any changes made to the data within the table.

\*/

CREATE OR REPLACE TRIGGER PROCESS\_NUMBER\_SEQ

BEFORE INSERT OR UPDATE ON MANUFACTURING FOR EACH ROW

BEGIN

IF :NEW.PROCESS\_NUMBER IS NULL THEN

:NEW.PROCESS\_NUMBER :=PROCESS\_NUMBER\_SEQ.NEXTVAL;

END IF;

IF INSERTING THEN

IF :NEW.CREATED\_BY IS NULL THEN :NEW.CREATED\_BY := USER; END IF;

IF :NEW.DATE\_CREATED IS NULL THEN :NEW.DATE\_CREATED := SYSDATE; END IF;

END IF;

IF INSERTING OR UPDATING THEN

IF :NEW.MODIFIED\_BY IS NULL THEN :NEW.MODIFIED\_BY := USER; END IF;

IF :NEW.DATE\_MODIFIED IS NULL THEN :NEW.DATE\_MODIFIED :=SYSDATE; END IF;

END IF;

END;

/

-- REQUEST\_ID sequence and request table audit columns trigger

/\*

REQUEST\_ID and REQUEST table audit columns trigger, business rule:

each request submission has a unique number assigned to it.

This aids in traceability of each request submitted to a vendor and can be

used as a reference by the Vendor when contacting the plant regarding a request.

This ID aids in differentiating scheduled requests,

or requests that are submitted routinely for the same quantities and materials

because a rate of material use has been established.

Additional audit columns are automatically populated in this trigger

to trace any changes made to the data within the table.

\*/

CREATE OR REPLACE TRIGGER REQUEST\_ID\_SEQ

BEFORE INSERT OR UPDATE ON REQUEST FOR EACH ROW

BEGIN

IF :NEW.REQUEST\_ID IS NULL THEN

:NEW.REQUEST\_ID :=REQUEST\_ID\_SEQ.NEXTVAL;

END IF;

IF INSERTING THEN

IF :NEW.CREATED\_BY IS NULL THEN :NEW.CREATED\_BY := USER; END IF;

IF :NEW.DATE\_CREATED IS NULL THEN :NEW.DATE\_CREATED := SYSDATE; END IF;

END IF;

IF INSERTING OR UPDATING THEN

IF :NEW.MODIFIED\_BY IS NULL THEN :NEW.MODIFIED\_BY := USER; END IF;

IF :NEW.DATE\_MODIFIED IS NULL THEN :NEW.DATE\_MODIFIED :=SYSDATE; END IF;

END IF;

END;

/

-- MATERIAL\_ID sequence and material table audit columns trigger

/\*

MATERIAL\_ID and MATERIAL table audit columns trigger, business rule:

each material has a unique number assigned to it.

Many materials are used throughout the plant, and certain materials

may have similar names/descriptions and functions, but

they are only validated for certain processes (i.e. different pH probes are

used in the cell culture and purification departments, however, they

are manufactured by the same vendor and look very similar). The unique

material\_id helps to differentiate similar materials.

Additional audit columns are automatically populated in this trigger

to trace any changes made to the data within the table.

\*/

CREATE OR REPLACE TRIGGER MATERIAL\_ID\_SEQ

BEFORE INSERT OR UPDATE ON MATERIAL FOR EACH ROW

BEGIN

IF :NEW.MATERIAL\_ID IS NULL THEN

:NEW.MATERIAL\_ID :=MATERIAL\_ID\_SEQ.NEXTVAL;

END IF;

IF INSERTING THEN

IF :NEW.CREATED\_BY IS NULL THEN :NEW.CREATED\_BY := USER; END IF;

IF :NEW.DATE\_CREATED IS NULL THEN :NEW.DATE\_CREATED := SYSDATE; END IF;

END IF;

IF INSERTING OR UPDATING THEN

IF :NEW.MODIFIED\_BY IS NULL THEN :NEW.MODIFIED\_BY := USER; END IF;

IF :NEW.DATE\_MODIFIED IS NULL THEN :NEW.DATE\_MODIFIED :=SYSDATE; END IF;

END IF;

END;

/

/\* querying all objects and columns\*/

--tables

SELECT TABLE\_NAME, STATUS

FROM ALL\_TABLES

WHERE TABLE\_NAME IN ('STAFF', 'VENDOR', 'MANUFACTURING', 'REQUEST', 'MATERIAL');

--each column in the staff table

SELECT TABLE\_NAME, COLUMN\_NAME, DATA\_TYPE, DATA\_LENGTH, NULLABLE

FROM ALL\_TAB\_COLS t

WHERE TABLE\_NAME = 'STAFF';

--each column in the vendor table

SELECT TABLE\_NAME, COLUMN\_NAME, DATA\_TYPE, DATA\_LENGTH, NULLABLE

FROM ALL\_TAB\_COLS t

WHERE TABLE\_NAME = 'VENDOR';

--each column in the manufacturing table

SELECT TABLE\_NAME, COLUMN\_NAME, DATA\_TYPE, DATA\_LENGTH, NULLABLE

FROM ALL\_TAB\_COLS t

WHERE TABLE\_NAME = 'MANUFACTURING';

--each column in the request table

SELECT TABLE\_NAME, COLUMN\_NAME, DATA\_TYPE, DATA\_LENGTH, NULLABLE

FROM ALL\_TAB\_COLS t

WHERE TABLE\_NAME = 'REQUEST';

--each column in the material table

SELECT TABLE\_NAME, COLUMN\_NAME, DATA\_TYPE, DATA\_LENGTH, NULLABLE

FROM ALL\_TAB\_COLS t

WHERE TABLE\_NAME = 'MATERIAL';

--statement for checking all objects within the data dictionary

--Note: because the student schema database was used, those objects are also displayed

SELECT OBJECT\_NAME, STATUS, CREATED, LAST\_DDL\_TIME FROM USER\_OBJECTS;

**DML/SQL Query Statements Source Code**

/\*

insert statements

\*/

--staff values

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('JOE', 'DIRT', 1234567678, 098765431, 'Supervisor');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('JESS', 'DAY', 2475839890, 123782564, 'MA1');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('WINSTON', 'BISHOP', 5627890001, 345098710, 'MA1');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('SCHMIDT', 'SCHMIDT', 4789031134, 742028474, 'MA2');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('NICK', 'MILLER', 7832876483, 731243740, 'Supervisor');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('CECE', 'PARIKH', 7583920430, 572832950, 'MA2');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('ERNIE', 'TAGLIABOO', 9120184287, 498213048, 'MA1');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('ALY', 'NELSON', 7492482038, 248213466, 'Supervisor');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('JOAN', 'DAY', 4471284273, 32947263, 'MA2');

INSERT INTO STAFF(FIRST\_NAME, LAST\_NAME, PHONE, SSN, ACCESS\_LEVEL)

VALUES('ROBBY', 'MCFERRIN', 3450986372, 592156728, 'MA1');

--vendor values

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Beckman Coulter', 9524484848, 18002223333,

'beckman.coulter@outlook.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Mettler Toledo', 6781240842, 18902228945, 'mettler.toledo@outlook.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Fisher Scientific', 5738296999, 19004738294,

'fisher.scientific@hotmail.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Roche', 6124509998, 4738910483, 'roche.laboratories@outlook.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Grainger', 1800956444, 3940572346, 'grainger.contact@outlook.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Illumina', 2678840926, 9521364392, 'illumina.resources@gmail.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Uline', 1800295551, 8005203786, 'uline.corporate@outlook.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Cole Parmer', 1800323434, 20934719462, 'sales@coleparmer.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('McMaster-Carr', 6308300300, 10947233463, 'mcmastercarr@outlook.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Zoro', 9348961499, 94726343928, 'request@zoro.com');

INSERT INTO VENDOR(VENDOR\_NAME, VENDOR\_PHONE, VENDOR\_FAX, VENDOR\_EMAIL)

VALUES('Boston Scientific', 4679990000, 94246721,

'contact@bostonscientific.com');

--request values

--used FK values associated with each vendor/staff to verify all relationships

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(100, 230, 15, NULL, 0, SYSDATE,

'email vendor if there are questions');

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(115, 233, 50, '01-JAN-23', 1, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(130, 236, 15, '01-JAN-23', 0, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(145, 239, 100, NULL, 1, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(160, 242, 50, '01-FEB-23', 0, SYSDATE,

'email vendor if there are questions');

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(175, 245, 32, NULL, 0, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(190, 248, 75, NULL, 1, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(205, 251, 45, NULL, 1, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(220, 254, 15, NULL, 0, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(235, 257, 7, '01-MAY-23', 1, SYSDATE, NULL);

INSERT INTO REQUEST (VENDOR\_ID\_FK, REQUESTING\_STAFF, REQUEST\_QUANTITY,

DATE\_NEEDED, COMPLETION\_STATUS, DATE\_REQUESTED, NOTE)

VALUES(250, 257, 75, NULL, 0, SYSDATE, NULL);

--manufacturing values

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (230, 'pH probe standardization', SYSDATE, 1, 2, NULL);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (233, 'BSC cleaning', SYSDATE, 1, 1, NULL);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (236, 'CIP of bioreactor', '01-MAR-21', 1, 2, NULL);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (239, 'autoclave of assemblies', '09-DEC-20', 1, 1, 1);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (242, 'pH probe standardization', '12-FEB-20', 1, 3, 2);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (245, 'filter integrity test', '30-SEP-21', 1, 1, NULL);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (248, 'column packing', '01-OCT-21', 1, 2, 10);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (251, 'column san/store', '01-OCT-21', 0, 3, NULL);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (254, 'DO probe polarization', '02-NOV-21', 0, 1, NULL);

INSERT INTO MANUFACTURING (MANUFACTURING\_STAFF, PROCESS\_DESCRIPTION,

DATE\_USED, PROCESS\_STATUS, QUANTITY\_USED, WASTED\_MATERIALS)

VALUES (257, 'weight and dispense', '02-NOV-21', 1, 1, 9);

--material values

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(500, 100, 100, '31-DEC-2023', NULL,

'7.00 pH buffer', 60, 'Room 1003', 25.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(503, 120, 115, '31-DEC-2023', 'Flammable',

'IPA Bottle, isopropyl alcohol 95%', 200, 'Room 1000', 10.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(506, 140, 130, '01-JAN-2024', NULL,

'pH probe', 150, 'Room 1500', 45.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(509, 160, 145, NULL, NULL,

'5ft silicone tubing', 100, 'Room 1100', 40.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(512, 180, 160, '15-MAR-2023', 'Carcinogenic',

'tryphan blue', 5, 'Room 1100', 55.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(515, 200, 175, NULL, NULL,

'6" round filters', 75, 'Room 1100', 155.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(518, 220, 190, NULL, NULL,

'resin', 30, 'Room 1100', 1000.00);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(521, 240, 205, '01-JAN-25', NULL,

'8.00pH buffer', 36, 'Room 1003', 19.45);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(524, 260, 220, NULL, 'High Pressure',

'N2 gas', 1000, 'Room 1100', 0.75);

INSERT INTO MATERIAL(REQUEST\_ID\_FK, PROCESS\_NUMBER\_FK, VENDOR\_ID\_REQUEST\_FK,

EXPIRATION\_DATE, HAZARD\_LEVEL, MATERIAL\_NAME, QUANTITY\_AVAILABLE,

STORAGE\_LOCATION, PRICE)

VALUES(527, 280, 235, NULL, NULL,

'sodium hydroxide powder', 53, 'Room 1003', 23.69);

--commit inserted statements

COMMIT;

--Queries/Select statements

--QUERY 1: SELECT all columns and all rows from one table

--BUSINESS PURPOSE: THIS QUERY SHOWS ALL INFORMATION ABOUT ALL VENDORS

SELECT \* FROM VENDOR;

--QUERY 2: Select 5 columns and all rows from one table

--BUSINESS RULE: This query displays characteristics of the materials

--currently stored in the database

SELECT MATERIAL\_ID, MATERIAL\_NAME, EXPIRATION\_DATE, HAZARD\_LEVEL,

QUANTITY\_AVAILABLE FROM MATERIAL;

--QUERY 3: Select all columns and all rows from one view

/\*

BUSINESS RULE: THIS QUERY DISPLAYS THE VIEW VW\_REQUEST WHICH DISPLAYS THE

REQUEST INFORMATION SUCH AS VENDOR AND MATERIAL DATA AND QUANTITY

\*/

SELECT \* FROM VW\_REQUEST;

/\*

QUERY 4: Using a join on 2 tables, select all columns and all rows from

the tables without the use of a Cartesian product

BUSINESS RULE: THIS QUERY DISPLAYS THE VENDOR AND WHAT MATERIALS THEY PRODUCE,

ALONG WITH THE MOST RECENT REQUEST NUMBER FOR EACH MATERIAL PRODUCED

BY THE VENDOR

\*/

SELECT \* FROM VENDOR v JOIN MATERIAL m ON v.VENDOR\_ID=m.VENDOR\_ID\_REQUEST\_FK;

--QUERY 5: Select and order data retrieved from one table

/\*BUSINESS RULE: This query displays the materials currently in inventory and displays the quantities available in inventory, ordered by the quantity available in ASC order\*/

SELECT MATERIAL\_NAME, QUANTITY\_AVAILABLE FROM MATERIAL

ORDER BY QUANTITY\_AVAILABLE ASC;

/\*QUERY 6: Using a join on 3 tables, select 5 columns from the 3 tables.

Use syntax that would limit the output to 10 rows.

BUSINESS RULE: This query displays the full staff members name, request ID number and description of the material requested.\*/

SELECT s.FIRST\_NAME|| ' ' || s.LAST\_NAME AS STAFF\_NAME, r.REQUEST\_ID,

m.MATERIAL\_NAME, m.MATERIAL\_ID FROM STAFF s JOIN REQUEST r ON

s.STAFF\_ID=r.REQUESTING\_STAFF JOIN MATERIAL m ON m.REQUEST\_ID\_FK=r.REQUEST\_ID

GROUP BY s.FIRST\_NAME, s.LAST\_NAME,

r.REQUEST\_ID, m.MATERIAL\_NAME, m.MATERIAL\_ID FETCH FIRST 10 ROWS ONLY;

--Query 7: Select distinct rows using joins on 3 tables

/\*Business Rule: This query displays all of the processes that use

hazardous materials and staff who have performed the process\*/

SELECT m.MATERIAL\_NAME, m.HAZARD\_LEVEL, p.PROCESS\_DESCRIPTION,

s.FIRST\_NAME || ' ' || s.LAST\_NAME AS STAFF\_NAME FROM MATERIAL m JOIN

MANUFACTURING p ON m.PROCESS\_NUMBER\_FK=p.PROCESS\_NUMBER JOIN STAFF s ON

s.STAFF\_ID=p.MANUFACTURING\_STAFF WHERE m.HAZARD\_LEVEL IS NOT NULL ORDER BY

m.MATERIAL\_ID, m.HAZARD\_LEVEL, p.PROCESS\_DESCRIPTION, s.FIRST\_NAME,

s.LAST\_NAME;

--Query 8: Use GROUP BY and HAVING in a SELECT statement using one or more tables

/\*Business Rule: This statement displays the total amount of wasted materials

during each process where the total wasted was greater than 5.

\*/

SELECT SUM(p.WASTED\_MATERIALS) AS TOTAL\_WASTED, m.MATERIAL\_NAME FROM

MANUFACTURING p JOIN MATERIAL m ON m.PROCESS\_NUMBER\_FK = p.PROCESS\_NUMBER

GROUP BY p.WASTED\_MATERIALS, m.MATERIAL\_NAME HAVING SUM(WASTED\_MATERIALS)>5;

--Query 9: Use IN clause to select data from one or more tables

/\*Business Rule: The statement below shows all staff who have performed the

process 'pH probe standardization' and offers another route of identifying staff

trained on the process

\*/

SELECT s.FIRST\_NAME || ' ' || s.LAST\_NAME AS STAFF\_NAME, p.DATE\_USED FROM STAFF s

JOIN MANUFACTURING p ON p.MANUFACTURING\_STAFF=s.STAFF\_ID WHERE

p.PROCESS\_DESCRIPTION IN ('pH probe standardization') ORDER BY s.FIRST\_NAME,

s.LAST\_NAME, p.DATE\_USED;

--Query 10: select length of one column from one table (use LENGTH function)

/\*Business Rule: This statement displays the length of each staffs full name,

can be used to determine the average space required to store each staff's name

in the database\*/

SELECT FIRST\_NAME || ' ' || LAST\_NAME AS FULL\_NAME, LENGTH(LAST\_NAME)

"NAME LENGTH" FROM STAFF;

/\*Query 11: Delete one record from one table. Use select statements to

demonstrate the table contents before and after the DELETE statement.

Make sure you use ROLLBACK afterwards

so that the data will not be physically removed

Business Rule: This statement demonstrates how to remove a material from the

database, which may be used when a material is no longer used at plant #111.

\*/

SELECT \* FROM MATERIAL;

DELETE FROM MATERIAL WHERE MATERIAL\_NAME='N2 gas';

SELECT \* FROM MATERIAL;

--REVERT THE CHANGE

ROLLBACK;

/\*QUERY 12: Update one record from one table. Use select statements to

demonstrate the table contents before and after the UPDATE statement.

Make sure you use ROLLBACK afterwards so that the data will not be

physically removed

Business Rule: This statement changes the current storage location of the

material resin to room 1500.

\*/

SELECT \* FROM MATERIAL WHERE MATERIAL\_NAME='resin';

UPDATE MATERIAL SET STORAGE\_LOCATION='1500' WHERE MATERIAL\_NAME='resin';

SELECT \* FROM MATERIAL WHERE MATERIAL\_NAME='resin';

--KEEP UPDATE

COMMIT;

/\*Query 13: Advanced Query

Business Rule: This statement displays the average quantity requested for each

material\*/

SELECT m.MATERIAL\_NAME, AVG(r.REQUEST\_QUANTITY)AS AVERAGE\_QUANTITY FROM

MATERIAL m JOIN REQUEST r ON r.REQUEST\_ID=m.REQUEST\_ID\_FK

GROUP BY m.MATERIAL\_NAME, r.REQUEST\_QUANTITY ORDER BY AVG(r.REQUEST\_QUANTITY)ASC;

/\*Query 14: Advanced Query

Business Rule: This statement displays the number of processes each staff member

has performed\*/

SELECT s.FIRST\_NAME || ' ' || s.LAST\_NAME AS STAFF\_NAME,(SELECT

COUNT(p.PROCESS\_NUMBER) FROM MANUFACTURING p WHERE

p.MANUFACTURING\_STAFF=s.STAFF\_ID)AS TOTAL\_PERFORMED FROM STAFF s;

/\* Query 15: Advanced Query

Business Rule: This statement displays the material and quantity used by each

employee\*/

SELECT t.FIRST\_NAME || ' ' || t.LAST\_NAME AS STAFF\_NAME, t.MATERIAL\_NAME,

SUM(t.QUANTITY\_USED) AS MATERIALS\_USED FROM

(SELECT s.FIRST\_NAME, s.LAST\_NAME, m.MATERIAL\_NAME, p.QUANTITY\_USED FROM STAFF s JOIN

MANUFACTURING p ON s.STAFF\_ID=p.MANUFACTURING\_STAFF JOIN MATERIAL m ON

m.PROCESS\_NUMBER\_FK=p.PROCESS\_NUMBER)t GROUP BY t.FIRST\_NAME, t.LAST\_NAME,

t.MATERIAL\_NAME;

/\*Query 16: Advanced Query

Business Rule: This statement displays the total amount owed to each vendor

per request submitted, based upon the quantity of each material being requested

and the cost per material\*/

SELECT t.VENDOR\_NAME, t.MATERIAL\_NAME, SUM(t.REQUEST\_QUANTITY)\*t.PRICE

AS TOTAL\_OWED

FROM (SELECT v.VENDOR\_NAME, m.MATERIAL\_NAME, r.REQUEST\_QUANTITY, m.PRICE FROM

VENDOR v JOIN REQUEST r ON r.VENDOR\_ID\_FK=v.VENDOR\_ID JOIN MATERIAL m ON

m.REQUEST\_ID\_FK=r.REQUEST\_ID)t GROUP BY t.VENDOR\_NAME, t.MATERIAL\_NAME,

t.REQUEST\_QUANTITY, t.PRICE;

/\*Query 17: Advanced Query

Business Rule: This statement displays the vendor who supplies the most

expensive material, along with the product description and price\*/

SELECT v.VENDOR\_NAME, m.MATERIAL\_NAME, m.PRICE FROM

VENDOR v JOIN REQUEST r ON v.VENDOR\_ID=r.VENDOR\_ID\_FK

JOIN MATERIAL m ON m.REQUEST\_ID\_FK=r.REQUEST\_ID WHERE m.PRICE IN

(SELECT MAX(PRICE) FROM MATERIAL) ORDER BY v.VENDOR\_NAME, m.MATERIAL\_NAME,

m.PRICE;

/\*Query 18: Advanced Query

Business Rule: This statement displays manufacturing processes with the

most expensive material cost first\*/

SELECT t.PROCESS\_DESCRIPTION, SUM(t.QUANTITY\_USED)\*t.PRICE AS PROCESS\_COST FROM

(SELECT p.PROCESS\_DESCRIPTION, p.QUANTITY\_USED, m.PRICE FROM MANUFACTURING p

JOIN MATERIAL m ON p.PROCESS\_NUMBER=m.PROCESS\_NUMBER\_FK)t GROUP BY

t.PROCESS\_DESCRIPTION, t.QUANTITY\_USED, t.PRICE ORDER BY PROCESS\_COST DESC;

/\*Query 19: Advanced Query

Business Rule: This statement displays vendors who have currently pending

requests, and the amount of each material that is pending\*/

SELECT t.VENDOR\_NAME, COUNT(t.REQUEST\_ID) AS PENDING\_REQUESTS,

SUM(t.REQUEST\_QUANTITY) AS QUANTITY\_PENDING\_MATERIALS, t.MATERIAL\_NAME

FROM(SELECT v.VENDOR\_NAME, r.REQUEST\_ID, r.REQUEST\_QUANTITY, m.MATERIAL\_NAME,

r.COMPLETION\_STATUS FROM VENDOR v JOIN REQUEST r ON v.VENDOR\_ID=r.VENDOR\_ID\_FK

JOIN MATERIAL m ON m.REQUEST\_ID\_FK=r.REQUEST\_ID)t WHERE

COMPLETION\_STATUS=0 GROUP BY t.VENDOR\_NAME, t.REQUEST\_ID, t.REQUEST\_QUANTITY,

t.MATERIAL\_NAME ORDER BY QUANTITY\_PENDING\_MATERIALS DESC;

/\*Query 20: Advanced Query

Business Rule: This statement displays all vendors who have pending requests,

with orders that are needed within 3 months\*/

SELECT t.VENDOR\_NAME, t.DATE\_NEEDED, t.COMPLETION\_STATUS, MONTHS\_BETWEEN(SYSDATE,

t.DATE\_NEEDED)\*-1 AS MONTHS\_UNTIL\_NEEDED FROM

(SELECT v.VENDOR\_NAME, r.DATE\_NEEDED, r.COMPLETION\_STATUS FROM VENDOR v

JOIN REQUEST r ON v.VENDOR\_ID=r.VENDOR\_ID\_FK)t WHERE t.COMPLETION\_STATUS= 0 AND

t.DATE\_NEEDED IS NOT NULL AND (MONTHS\_BETWEEN(SYSDATE,

t.DATE\_NEEDED)\*-1)<3

GROUP BY t.VENDOR\_NAME, t.DATE\_NEEDED, t.COMPLETION\_STATUS;

**DDL, DML and Query Output**

**DDL Output**

Table STAFF dropped.

Table VENDOR dropped.

Table MANUFACTURING dropped.

Table REQUEST dropped.

Table MATERIAL dropped.

Sequence STAFF\_ID\_SEQ dropped.

Sequence VENDOR\_ID\_SEQ dropped.

Sequence PROCESS\_NUMBER\_SEQ dropped.

Sequence REQUEST\_ID\_SEQ dropped.

Sequence MATERIAL\_ID\_SEQ dropped.

Table STAFF created.

Table VENDOR created.

Table MANUFACTURING created.

Table REQUEST created.

Table MATERIAL created.

Index MANUFACTURING\_STAFF\_FK created.

Index REQUEST\_VENDOR\_FK created.

Index REQUEST\_STAFF\_FK created.

Index MATERIAL\_REQUEST\_FK created.

Index MATERIAL\_MANUFACTURING\_FK created.

INDEX VENDOR\_NAME\_UX created.

Index VENDOR\_PHONE\_UX created.

Index STAFF\_LAST\_NAME\_UX created.

Index STAFF\_FIRST\_NAME\_US created.

Index MANUFACTURING\_QUANTITY\_USED\_UX created.

Index REQUEST\_QUANTITY\_UX created.

Index REQUEST\_DATE\_REQUESTED\_UX created.

Index REQUEST\_DATE\_NEEDED\_UX created.

Index MATERIAL\_EXPIRATION\_DATE\_UX created.

Index MATERIAL\_HAZARD\_LEVEL\_UX created.

Table STAFF altered.

Table VENDOR altered.

Table MANUFACTURING altered.

Table REQUEST altered.

Table MATERIAL altered.

View VW\_STAFF created.

View VW\_VENDOR created.

View VW\_REQUEST created.

View VW\_MANUFACTURING created.

View VW\_MATERIAL created.

Sequence STAFF\_ID\_SEQ created.

Sequence VENDOR\_ID\_SEQ created.

Sequence PROCESS\_NUMBER\_SEQ created.

Sequence REQUEST\_ID\_SEQ created.

Sequence MATERIAL\_ID\_SEQ created.

Trigger STAFF\_ID\_SEQ compiled

Trigger VENDOR\_ID\_SEQ compiled

Trigger PROCESS\_NUMBER\_SEQ compiled

Trigger REQUEST\_ID\_SEQ compiled

Trigger MATERIAL\_ID\_SEQ compiled

TABLE\_NAME STATUS

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STAFF VALID

VENDOR VALID

MANUFACTURING VALID

REQUEST VALID

MATERIAL VALID

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

-------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- ----------- -

STAFF STAFF\_ID NUMBER 22 N

STAFF LAST\_NAME VARCHAR2 50 N

STAFF FIRST\_NAME VARCHAR2 50 N

STAFF PHONE NUMBER 22 N

STAFF DOB DATE 7 Y

STAFF SSN NUMBER 22 N

STAFF ACCESS\_LEVEL VARCHAR2 15 N

STAFF CREATED\_BY VARCHAR2 30 Y

STAFF DATE\_CREATED DATE 7 Y

STAFF MODIFIED\_BY VARCHAR2 30 Y

STAFF DATE\_MODIFIED DATE 7 Y

11 rows selected.

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

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VENDOR VENDOR\_ID NUMBER 22 N

VENDOR VENDOR\_EMAIL VARCHAR2 100 N

VENDOR VENDOR\_PHONE NUMBER 22 N

VENDOR VENDOR\_NAME VARCHAR2 50 N

VENDOR VENDOR\_FAX NUMBER 22 Y

VENDOR CREATED\_BY VARCHAR2 30 Y

VENDOR DATE\_CREATED DATE 7 Y

VENDOR MODIFIED\_BY VARCHAR2 30 Y

VENDOR DATE\_MODIFIED DATE 7 Y

9 rows selected.

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

-------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- ----------- -

MANUFACTURING PROCESS\_NUMBER NUMBER 22 N

MANUFACTURING PROCESS\_DESCRIPTION VARCHAR2 30 Y

MANUFACTURING MANUFACTURING\_STAFF NUMBER 22 N

MANUFACTURING DATE\_USED DATE 7 Y

MANUFACTURING PROCESS\_STATUS NUMBER 22 Y

MANUFACTURING QUANTITY\_USED NUMBER 22 N

MANUFACTURING WASTED\_MATERIALS NUMBER 22 Y

MANUFACTURING CREATED\_BY VARCHAR2 30 Y

MANUFACTURING DATE\_CREATED DATE 7 Y

MANUFACTURING MODIFIED\_BY VARCHAR2 30 Y

MANUFACTURING DATE\_MODIFIED DATE 7 Y

11 rows selected.

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

-------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- ----------- -

REQUEST REQUEST\_ID NUMBER 22 N

REQUEST VENDOR\_ID\_FK NUMBER 22 N

REQUEST REQUESTING\_STAFF NUMBER 22 N

REQUEST REQUEST\_QUANTITY NUMBER 22 N

REQUEST DATE\_NEEDED DATE 7 Y

REQUEST COMPLETION\_STATUS NUMBER 22 N

REQUEST DATE\_REQUESTED DATE 7 N

REQUEST NOTE VARCHAR2 500 Y

REQUEST CREATED\_BY VARCHAR2 30 Y

REQUEST DATE\_CREATED DATE 7 Y

REQUEST MODIFIED\_BY VARCHAR2 30 Y

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

-------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- ----------- -

REQUEST DATE\_MODIFIED DATE 7 Y

12 rows selected.

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

-------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- ----------- -

MATERIAL MATERIAL\_ID NUMBER 22 N

MATERIAL REQUEST\_ID\_FK NUMBER 22 N

MATERIAL PROCESS\_NUMBER\_FK NUMBER 22 Y

MATERIAL VENDOR\_ID\_REQUEST\_FK NUMBER 22 N

MATERIAL EXPIRATION\_DATE DATE 7 Y

MATERIAL HAZARD\_LEVEL VARCHAR2 20 Y

MATERIAL MATERIAL\_NAME VARCHAR2 75 N

MATERIAL QUANTITY\_AVAILABLE NUMBER 22 N

MATERIAL STORAGE\_LOCATION VARCHAR2 20 N

MATERIAL PRICE NUMBER 22 N

MATERIAL CREATED\_BY VARCHAR2 30 Y

TABLE\_NAME COLUMN\_NAME DATA\_TYPE DATA\_LENGTH N

-------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- -------------------------------------------------------------------------------------------------------------------------------- ----------- -

MATERIAL DATE\_CREATED DATE 7 Y

MATERIAL MODIFIED\_BY VARCHAR2 30 Y

MATERIAL DATE\_MODIFIED DATE 7 Y

14 rows selected.

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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INSTRUCTOR\_ID\_SEQ VALID 16-FEB-22 16-FEB-22

SECTION\_ID\_SEQ VALID 16-FEB-22 16-FEB-22

STUDENT\_ID\_SEQ VALID 16-FEB-22 16-FEB-22

COURSE\_NO\_SEQ VALID 16-FEB-22 16-FEB-22

COURSE VALID 16-FEB-22 16-FEB-22

CRSE\_CRSE\_FK\_I VALID 16-FEB-22 16-FEB-22

CRSE\_PK VALID 16-FEB-22 16-FEB-22

ENROLLMENT VALID 16-FEB-22 16-FEB-22

ENR\_SECT\_FK\_I VALID 16-FEB-22 16-FEB-22

ENR\_PK VALID 16-FEB-22 16-FEB-22

GRADE VALID 16-FEB-22 16-FEB-22

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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GR\_GRTW\_FK\_I VALID 16-FEB-22 16-FEB-22

GR\_PK VALID 16-FEB-22 16-FEB-22

GRADE\_CONVERSION VALID 16-FEB-22 16-FEB-22

GRCON\_PK VALID 16-FEB-22 16-FEB-22

GRADE\_TYPE VALID 16-FEB-22 16-FEB-22

GRTYP\_PK VALID 16-FEB-22 16-FEB-22

GRADE\_TYPE\_WEIGHT VALID 16-FEB-22 16-FEB-22

GRTW\_GRTYP\_FK\_I VALID 16-FEB-22 16-FEB-22

GRTW\_PK VALID 16-FEB-22 16-FEB-22

INSTRUCTOR VALID 16-FEB-22 03-OCT-22

INST\_ZIP\_FK\_I VALID 16-FEB-22 16-FEB-22

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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INST\_PK VALID 16-FEB-22 16-FEB-22

SECTION VALID 16-FEB-22 16-FEB-22

SECT\_CRSE\_FK\_I VALID 16-FEB-22 16-FEB-22

SECT\_INST\_FK\_I VALID 16-FEB-22 16-FEB-22

SECT\_PK VALID 16-FEB-22 16-FEB-22

SECT\_SECT2\_UK VALID 16-FEB-22 16-FEB-22

STUDENT VALID 16-FEB-22 16-FEB-22

STU\_ZIP\_FK\_I VALID 16-FEB-22 16-FEB-22

STU\_PK VALID 16-FEB-22 16-FEB-22

ZIPCODE VALID 16-FEB-22 16-FEB-22

ZIP\_PK VALID 16-FEB-22 16-FEB-22

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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VW\_STAFF VALID 07-OCT-22 31-OCT-22

VW\_VENDOR VALID 07-OCT-22 31-OCT-22

VW\_REQUEST VALID 07-OCT-22 31-OCT-22

VW\_MANUFACTURING VALID 07-OCT-22 31-OCT-22

VW\_MATERIAL VALID 07-OCT-22 31-OCT-22

STAFF\_ID\_SEQUENCE VALID 07-OCT-22 07-OCT-22

MATERIAL\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

STAFF VALID 31-OCT-22 31-OCT-22

SYS\_C0017763 VALID 31-OCT-22 31-OCT-22

VENDOR VALID 31-OCT-22 31-OCT-22

SYS\_C0017768 VALID 31-OCT-22 31-OCT-22

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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MANUFACTURING VALID 31-OCT-22 31-OCT-22

SYS\_C0017772 VALID 31-OCT-22 31-OCT-22

REQUEST VALID 31-OCT-22 31-OCT-22

PK\_REQUEST VALID 31-OCT-22 31-OCT-22

MATERIAL VALID 31-OCT-22 31-OCT-22

PK\_MATERIAL VALID 31-OCT-22 31-OCT-22

MANUFACTURING\_STAFF\_FK VALID 31-OCT-22 31-OCT-22

REQUEST\_VENDOR\_FK VALID 31-OCT-22 31-OCT-22

REQUEST\_STAFF\_FK VALID 31-OCT-22 31-OCT-22

MATERIAL\_REQUEST\_FK VALID 31-OCT-22 31-OCT-22

MATERIAL\_MANUFACTURING\_FK VALID 31-OCT-22 31-OCT-22

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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VENDOR\_NAME\_UX VALID 31-OCT-22 31-OCT-22

VENDOR\_PHONE\_UX VALID 31-OCT-22 31-OCT-22

STAFF\_LAST\_NAME\_UX VALID 31-OCT-22 31-OCT-22

STAFF\_FIRST\_NAME\_US VALID 31-OCT-22 31-OCT-22

MANUFACTURING\_QUANTITY\_USED\_UX VALID 31-OCT-22 31-OCT-22

REQUEST\_QUANTITY\_UX VALID 31-OCT-22 31-OCT-22

REQUEST\_DATE\_REQUESTED\_UX VALID 31-OCT-22 31-OCT-22

REQUEST\_DATE\_NEEDED\_UX VALID 31-OCT-22 31-OCT-22

MATERIAL\_EXPIRATION\_DATE\_UX VALID 31-OCT-22 31-OCT-22

MATERIAL\_HAZARD\_LEVEL\_UX VALID 31-OCT-22 31-OCT-22

STAFF\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

OBJECT\_NAME STATUS CREATED LAST\_DDL\_

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VENDOR\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

PROCESS\_NUMBER\_SEQ VALID 31-OCT-22 31-OCT-22

REQUEST\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

MATERIAL\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

STAFF\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

VENDOR\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

PROCESS\_NUMBER\_SEQ VALID 31-OCT-22 31-OCT-22

REQUEST\_ID\_SEQ VALID 31-OCT-22 31-OCT-22

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VENDOR\_ID VENDOR\_EMAIL VENDOR\_PHONE VENDOR\_NAME VENDOR\_FAX CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI

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100 beckman.coulter@outlook.com 9524484848 Beckman Coulter 1.8002E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

115 mettler.toledo@outlook.com 6781240842 Mettler Toledo 1.8902E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

130 fisher.scientific@hotmail.com 5738296999 Fisher Scientific 1.9005E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

145 roche.laboratories@outlook.com 6124509998 Roche 4738910483 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

160 grainger.contact@outlook.com 1800956444 Grainger 3940572346 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

175 illumina.resources@gmail.com 2678840926 Illumina 9521364392 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

190 uline.corporate@outlook.com 1800295551 Uline 8005203786 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

205 sales@coleparmer.com 1800323434 Cole Parmer 2.0935E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

220 mcmastercarr@outlook.com 6308300300 McMaster-Carr 1.0947E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

235 request@zoro.com 9348961499 Zoro 9.4726E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

250 contact@bostonscientific.com 4679990000 Boston Scientific 94246721 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

11 rows selected.

MATERIAL\_ID MATERIAL\_NAME EXPIRATIO HAZARD\_LEVEL QUANTITY\_AVAILABLE

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1500 7.00 pH buffer 31-DEC-23 60

1520 IPA Bottle, isopropyl alcohol 95% 31-DEC-23 Flammable 200

1540 pH probe 01-JAN-24 150

1560 5ft silicone tubing 100

1580 tryphan blue 15-MAR-23 Carcinogenic 5

1600 6" round filters 75

1620 resin 30

1640 8.00pH buffer 01-JAN-25 36

1660 N2 gas High Pressure 1000

1680 sodium hydroxide powder 53

10 rows selected.

REQUEST\_ID DATE\_REQU VENDOR\_ID\_FK REQUEST\_QUANTITY COMPLETION\_STATUS MATERIAL\_ID MATERIAL\_NAME

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500 31-OCT-22 100 15 0 1500 7.00 pH buffer

503 31-OCT-22 115 50 1 1520 IPA Bottle, isopropyl alcohol 95%

506 31-OCT-22 130 15 0 1540 pH probe

509 31-OCT-22 145 100 1 1560 5ft silicone tubing

512 31-OCT-22 160 50 0 1580 tryphan blue

515 31-OCT-22 175 32 0 1600 6" round filters

518 31-OCT-22 190 75 1 1620 resin

521 31-OCT-22 205 45 1 1640 8.00pH buffer

524 31-OCT-22 220 15 0 1660 N2 gas

527 31-OCT-22 235 7 1 1680 sodium hydroxide powder

10 rows selected.

VENDOR\_ID VENDOR\_EMAIL VENDOR\_PHONE VENDOR\_NAME VENDOR\_FAX CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI MATERIAL\_ID REQUEST\_ID\_FK PROCESS\_NUMBER\_FK VENDOR\_ID\_REQUEST\_FK EXPIRATIO HAZARD\_LEVEL MATERIAL\_NAME QUANTITY\_AVAILABLE STORAGE\_LOCATION PRICE CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI

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100 beckman.coulter@outlook.com 9524484848 Beckman Coulter 1.8002E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1500 500 100 100 31-DEC-23 7.00 pH buffer 60 Room 1003 25 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

115 mettler.toledo@outlook.com 6781240842 Mettler Toledo 1.8902E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1520 503 120 115 31-DEC-23 Flammable IPA Bottle, isopropyl alcohol 95% 200 Room 1000 10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

130 fisher.scientific@hotmail.com 5738296999 Fisher Scientific 1.9005E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1540 506 140 130 01-JAN-24 pH probe 150 Room 1500 45 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

145 roche.laboratories@outlook.com 6124509998 Roche 4738910483 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1560 509 160 145 5ft silicone tubing 100 Room 1100 40 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

160 grainger.contact@outlook.com 1800956444 Grainger 3940572346 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1580 512 180 160 15-MAR-23 Carcinogenic tryphan blue 5 Room 1100 55 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

175 illumina.resources@gmail.com 2678840926 Illumina 9521364392 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1600 515 200 175 6" round filters 75 Room 1100 155 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

190 uline.corporate@outlook.com 1800295551 Uline 8005203786 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1620 518 220 190 resin 30 Room 1100 1000 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

205 sales@coleparmer.com 1800323434 Cole Parmer 2.0935E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1640 521 240 205 01-JAN-25 8.00pH buffer 36 Room 1003 19 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

220 mcmastercarr@outlook.com 6308300300 McMaster-Carr 1.0947E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1660 524 260 220 High Pressure N2 gas 1000 Room 1100 1 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

235 request@zoro.com 9348961499 Zoro 9.4726E+10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22 1680 527 280 235 sodium hydroxide powder 53 Room 1003 24 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

10 rows selected.

MATERIAL\_NAME QUANTITY\_AVAILABLE

--------------------------------------------------------------------------- ------------------

tryphan blue 5

resin 30

8.00pH buffer 36

sodium hydroxide powder 53

7.00 pH buffer 60

6" round filters 75

5ft silicone tubing 100

pH probe 150

IPA Bottle, isopropyl alcohol 95% 200

N2 gas 1000

10 rows selected.

STAFF\_NAME REQUEST\_ID MATERIAL\_NAME MATERIAL\_ID

----------------------------------------------------------------------------------------------------- ---------- --------------------------------------------------------------------------- -----------

ALY NELSON 521 8.00pH buffer 1640

ROBBY MCFERRIN 527 sodium hydroxide powder 1680

WINSTON BISHOP 506 pH probe 1540

NICK MILLER 512 tryphan blue 1580

CECE PARIKH 515 6" round filters 1600

JESS DAY 503 IPA Bottle, isopropyl alcohol 95% 1520

JOE DIRT 500 7.00 pH buffer 1500

SCHMIDT SCHMIDT 509 5ft silicone tubing 1560

ERNIE TAGLIABOO 518 resin 1620

JOAN DAY 524 N2 gas 1660

10 rows selected.

MATERIAL\_NAME HAZARD\_LEVEL PROCESS\_DESCRIPTION STAFF\_NAME

--------------------------------------------------------------------------- -------------------- ------------------------------ -----------------------------------------------------------------------------------------------------

IPA Bottle, isopropyl alcohol 95% Flammable BSC cleaning JESS DAY

tryphan blue Carcinogenic pH probe standardization NICK MILLER

N2 gas High Pressure DO probe polarization JOAN DAY

TOTAL\_WASTED MATERIAL\_NAME

------------ ---------------------------------------------------------------------------

10 resin

9 sodium hydroxide powder

STAFF\_NAME DATE\_USED

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JOE DIRT 31-OCT-22

NICK MILLER 12-FEB-20

FULL\_NAME NAME LENGTH

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WINSTON BISHOP 6

JESS DAY 3

JOAN DAY 3

JOE DIRT 4

ROBBY MCFERRIN 8

NICK MILLER 6

ALY NELSON 6

CECE PARIKH 6

SCHMIDT SCHMIDT 7

ERNIE TAGLIABOO 9

10 rows selected.

MATERIAL\_ID REQUEST\_ID\_FK PROCESS\_NUMBER\_FK VENDOR\_ID\_REQUEST\_FK EXPIRATIO HAZARD\_LEVEL MATERIAL\_NAME QUANTITY\_AVAILABLE STORAGE\_LOCATION PRICE CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI

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1500 500 100 100 31-DEC-23 7.00 pH buffer 60 Room 1003 25 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1520 503 120 115 31-DEC-23 Flammable IPA Bottle, isopropyl alcohol 95% 200 Room 1000 10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1540 506 140 130 01-JAN-24 pH probe 150 Room 1500 45 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1560 509 160 145 5ft silicone tubing 100 Room 1100 40 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1580 512 180 160 15-MAR-23 Carcinogenic tryphan blue 5 Room 1100 55 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1600 515 200 175 6" round filters 75 Room 1100 155 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1620 518 220 190 resin 30 Room 1100 1000 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1640 521 240 205 01-JAN-25 8.00pH buffer 36 Room 1003 19 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1660 524 260 220 High Pressure N2 gas 1000 Room 1100 1 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1680 527 280 235 sodium hydroxide powder 53 Room 1003 24 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

10 rows selected.

1 row deleted.

MATERIAL\_ID REQUEST\_ID\_FK PROCESS\_NUMBER\_FK VENDOR\_ID\_REQUEST\_FK EXPIRATIO HAZARD\_LEVEL MATERIAL\_NAME QUANTITY\_AVAILABLE STORAGE\_LOCATION PRICE CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI

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1500 500 100 100 31-DEC-23 7.00 pH buffer 60 Room 1003 25 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1520 503 120 115 31-DEC-23 Flammable IPA Bottle, isopropyl alcohol 95% 200 Room 1000 10 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1540 506 140 130 01-JAN-24 pH probe 150 Room 1500 45 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1560 509 160 145 5ft silicone tubing 100 Room 1100 40 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1580 512 180 160 15-MAR-23 Carcinogenic tryphan blue 5 Room 1100 55 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1600 515 200 175 6" round filters 75 Room 1100 155 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1620 518 220 190 resin 30 Room 1100 1000 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1640 521 240 205 01-JAN-25 8.00pH buffer 36 Room 1003 19 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1680 527 280 235 sodium hydroxide powder 53 Room 1003 24 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

9 rows selected.

Rollback complete.

MATERIAL\_ID REQUEST\_ID\_FK PROCESS\_NUMBER\_FK VENDOR\_ID\_REQUEST\_FK EXPIRATIO HAZARD\_LEVEL MATERIAL\_NAME QUANTITY\_AVAILABLE STORAGE\_LOCATION PRICE CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI

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1620 518 220 190 resin 30 Room 1100 1000 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

1 row updated.

MATERIAL\_ID REQUEST\_ID\_FK PROCESS\_NUMBER\_FK VENDOR\_ID\_REQUEST\_FK EXPIRATIO HAZARD\_LEVEL MATERIAL\_NAME QUANTITY\_AVAILABLE STORAGE\_LOCATION PRICE CREATED\_BY DATE\_CREA MODIFIED\_BY DATE\_MODI

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1620 518 220 190 resin 30 1500 1000 DBST\_USER 31-OCT-22 DBST\_USER 31-OCT-22

Commit complete.

MATERIAL\_NAME AVERAGE\_QUANTITY

--------------------------------------------------------------------------- ----------------

sodium hydroxide powder 7

7.00 pH buffer 15

pH probe 15

N2 gas 15

6" round filters 32

8.00pH buffer 45

IPA Bottle, isopropyl alcohol 95% 50

tryphan blue 50

resin 75

5ft silicone tubing 100

10 rows selected.

STAFF\_NAME TOTAL\_PERFORMED

----------------------------------------------------------------------------------------------------- ---------------

JOE DIRT 1

JESS DAY 1

WINSTON BISHOP 1

SCHMIDT SCHMIDT 1

NICK MILLER 1

CECE PARIKH 1

ERNIE TAGLIABOO 1

ALY NELSON 1

JOAN DAY 1

ROBBY MCFERRIN 1

10 rows selected.

STAFF\_NAME MATERIAL\_NAME MATERIALS\_USED

----------------------------------------------------------------------------------------------------- --------------------------------------------------------------------------- --------------

JOE DIRT 7.00 pH buffer 2

SCHMIDT SCHMIDT 5ft silicone tubing 1

ROBBY MCFERRIN sodium hydroxide powder 1

ERNIE TAGLIABOO resin 2

JOAN DAY N2 gas 1

JESS DAY IPA Bottle, isopropyl alcohol 95% 1

WINSTON BISHOP pH probe 2

ALY NELSON 8.00pH buffer 3

NICK MILLER tryphan blue 3

CECE PARIKH 6" round filters 1

10 rows selected.

VENDOR\_NAME MATERIAL\_NAME TOTAL\_OWED

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Grainger tryphan blue 2750

Cole Parmer 8.00pH buffer 855

McMaster-Carr N2 gas 15

Zoro sodium hydroxide powder 168

Fisher Scientific pH probe 675

Uline resin 75000

Roche 5ft silicone tubing 4000

Illumina 6" round filters 4960

Beckman Coulter 7.00 pH buffer 375

Mettler Toledo IPA Bottle, isopropyl alcohol 95% 500

10 rows selected.

VENDOR\_NAME MATERIAL\_NAME PRICE

-------------------------------------------------- --------------------------------------------------------------------------- ----------

Uline resin 1000

PROCESS\_DESCRIPTION PROCESS\_COST

------------------------------ ------------

column packing 2000

pH probe standardization 165

filter integrity test 155

CIP of bioreactor 90

column san/store 57

pH probe standardization 50

autoclave of assemblies 40

weight and dispense 24

BSC cleaning 10

DO probe polarization 1

10 rows selected.

VENDOR\_NAME PENDING\_REQUESTS QUANTITY\_PENDING\_MATERIALS MATERIAL\_NAME

-------------------------------------------------- ---------------- -------------------------- ---------------------------------------------------------------------------

Grainger 1 50 tryphan blue

Illumina 1 32 6" round filters

McMaster-Carr 1 15 N2 gas

Fisher Scientific 1 15 pH probe

Beckman Coulter 1 15 7.00 pH buffer

VENDOR\_NAME DATE\_NEED COMPLETION\_STATUS MONTHS\_UNTIL\_NEEDED

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Fisher Scientific 01-JAN-23 0 2.00418309

## Database Administration and Monitoring

### Roles and Responsibilities

Security is an important aspect of the WMS and as such the security administrator will be an experienced IT staff member with cyber security experience, should it be necessary there can be more than one security administrator. The database administrator is any supervisor or manager within the manufacturing or warehouse departments, they will have an access level of ‘Supervisor’ within the ACCESS\_LEVEL attribute in the STAFF entity. All Database administrators must have received the appropriate training for entering and editing data within the WMS. The system administrator is the site head of plant #111, who will have an overall understanding of future uses of the system such as expansion of the WMS to other plants within LP such as possible development of a DDBMS across multiple sites.

### System Information

Server side-technologies are accessed by the client through UMGCs Virtual Desktop Access (VDA), they are run on an Intel(R) Xeon(R) Platinum 8370C CPU @ 2.80GHz processor that is a 64-bit operating system, x64-based processor and will be run on Windows 11 Pro version 21H2 with 8GB ram. User technologies will be accessed using Microsoft Edge Version 105.0.1343.33 (Official Build) 64-bit, run on Windows 10 Home version 21H2. Oracle SQL developer version 19.3.0.0 will be used to develop the database using the server side-technologies listed.

#### Database Management System Configuration

The following section describes the hardware and supporting software needed in theory to implement the WMS database for the UMGC project. The WMS simulates an enterprise level system, and the following discusses in theory how the DBMS would be configured.

#### Database Support Software

Support software includes Oracle SQL Developer 19c Enterprise Edition Release version 19.3.0.0 (Build MAIN 204.1703) will create and manipulate the database on a Windows 11 Pro Version 21H2 OS.

#### Security and Privacy

Data partitioning is used throughout the WMS so that all data is present in the database and relationships are built accordingly to relate necessary data, but only certain employees can access more sensitive data such as employee information or material cost. Additionally, the WMS will only be accessible through supported hardware in controlled locations within the plant such as clean rooms on the manufacturing floor or controlled access locations within the warehouse, which are only accessible by employees with allowable badge access. Lastly, upon implementation of the WMS to additionally increase security measures a Secure Sockets Layer (SSL) will be implemented to protect the connections between the user and the server which will be performed by a third-party vendor and is out of the scope of this project.

### Performance Monitoring and Database Efficiency

It will be the responsibility of the IT, manufacturing, and warehouse departments to review and keep up to date on the WMS performance. The manufacturing and warehouse departments will be responsible for the query metrics performance whereas the IT department is responsible for the server, security, updates, and databases space utilization.

#### Operational Implications

The IT department is the primary department responsible for the routine maintenance and updating of the WMS, including ensuring the hardware and servers are routinely monitored and updated as needed and that future updates to the Windows OS are performed without compromising production within the plant. Should downtime need to be scheduled for maintenance to the system, it is the responsibility of the IT department to schedule and update other departments of this downtime. A system will be put into place for submitting electronic tickets to the IT department should users encounter problems with the system, this incorporation is outside the scope of this project.

#### Data Transfer Requirements

Data transfer made to and from the system must be done using secure files and only by staff with a high enough access level, files are not allowed to be transferred to sources outside of the WMS unless authorized. The database must be run on a Windows 10 or higher OS, preferably Windows 11.

#### Data Formats

Data formats submitted to the database will be primarily text file or .csv files, most file types of output from the system will be either excel or .pdf files.

### Backup and Recovery

The WMS transaction log backups will occur every 12 hours to ensure daily material movements are not lost. Full DBMS backups will occur weekly on Mondays at 2pm, with this time being accounted for in the manufacturing schedule. Differential backups will store data in between the full back ups as an extra precaution. Each backup will be done automatically and is prompted by the server. It is the responsibility of the IT department to monitor and ensure these backups are occurring routinely. Additionally, shadow paging will be used as a recovery method in the event of a crash (GeeksforGeeks, 2022).

**Appendix A: Visual Diagrams**

Diagram

Description automatically generated

*Figure 1: ERD of the WMS Database*

**Appendix B: Acronyms**

**Table 1 - Acronyms**

|  |  |
| --- | --- |
| **Acronym** | **Literal Translation** |
| CIP | Clean in Place |
| DBMS | Database Management System |
| DO | Dissolved Oxygen |
| ERD | Entity Relationship Diagram |
| FIT | Filter Integrity Test |
| FK | Foreign Key |
| LP | Lead Pharmaceuticals |
| OS | Operating System |
| PK | Primary Key |
| SDLC | System Development Lifecyle |
| WMS | Warehouse Management System |

References

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