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Migration Guide: Amazon RDS for MySQL to HeatWave MySQL on Amazon Web Services (AWS)

Before you start:

- You must have an account on Oracle Cloud Infrastructure (OCI) and Amazon Web Services (AWS).
- You must have enabled HeatWave MySQL on AWS from the OCI Console. For instructions on how to enable HeatWave MySQL on AWS from OCI, refer to the documentation: https://dev.mysql.com/doc/heatwave-aws/en/heatwave-aws-getting-started.html
- Some OCI and AWS knowledge is preferred.
- This migration guide only covers how to migrate your database from Amazon RDS for MySQL (Amazon RDS MySQL) to HeatWave MySQL on AWS (HeatWave MySQL). Before performing the migration, you should have considered downtime (the length of the downtime will mostly depend on the size of your database and checks you may want to perform before bringing your database back online), application compatibility, current database metrics (CPU, storage size, RAM, max number of concurrent users, backups, binary logs expiration, number of replicas if any, etc.), desired database metrics, networking, security, user testing, etc.
- The migration method shown in this guide works for Amazon RDS MySQL v5.7 and above.
- When following the guide, you should always execute the commands/steps shown as an admin/root user wherever applicable.
    - On OCI and AWS you must have the ability to create and manage resources.
    - For your Amazon RDS MySQL instance, use an admin/root user.
- You do not need to make any configuration changes to your Amazon RDS MySQL for this migration.
- If you have MySQL replication configured in your current Amazon RDS MySQL environment, you can perform the migration steps shown in this guide from either your source or replica instance.
- The Overview section of this migration guide contains all the steps that are needed to finish the database migration from Amazon RDS MySQL to HeatWave MySQL on AWS.
- In the Walkthrough section, we will apply the information provided in the Overview section and give you a simple step-by-step guide. In this guide, we will use an Amazon RDS MySQL instance with some sample data pre-loaded and will migrate it over to HeatWave MySQL on AWS. This will help you follow and better visualize the process and information provided in the Overview section.
- You can use the Walkthrough section's step-by-step guide as a reference for your migration from Amazon RDS MySQL to HeatWave MySQL. When following the guide, make changes along the way to your AWS and OCI environment accordingly or as required. Since each user following the step-by-step guide will have their environments configured differently, we will not be able to provide an ideal example that works for everyone.

Overview:

Following are the required steps to migrate data from Amazon RDS MySQL to HeatWave MySQL on AWS:

I) Have an Oracle Cloud Infrastructure (OCI) and Amazon Web Services (AWS) account.

OCI Sign in/Sign up page: https://cloud.oracle.com
AWS Sign in/Sign up page: https://aws.amazon.com

II) Ensure you can access the HeatWave MySQL on AWS Console after enabling the HeatWave MySQL on AWS service on OCI.

Enabling HeatWave MySQL on AWS service: https://dev.mysql.com/doc/heatwave-aws/en/heatwave-aws-getting-started.html
HeatWave MySQL on AWS Console: https://cloud.mysql.com/

III) On AWS, create an access key and an S3 bucket.

[The Amazon RDS MySQL data will be exported to an S3 bucket, which will then be later imported into HeatWave MySQL on AWS. You must create the AWS S3 bucket in the same region where your HeatWave MySQL on AWS DB System will reside. An AWS access key is required to grant secure access to the AWS S3 bucket. The user creating the access key must have the AmazonS3FullAccess permissions policy.]
Creating access keys for the root user: https://docs.aws.amazon.com/IAM/latest/UserGuide/id_root-user_manage_add-key.html
AmazonS3FullAccess Policy: https://docs.aws.amazon.com/aws-managed-policy/latest/reference/AmazonS3FullAccess.html
Creating a bucket: https://docs.aws.amazon.com/AmazonS3/latest/userguide/create-bucket-overview.html

IV) Install MySQL Shell 8.3 (or above) on an EC2 instance that can connect to Amazon RDS MySQL and create a credentials file.

[MySQL Shell on EC2 will be used to copy DDL and data from Amazon RDS MySQL to the AWS S3 bucket. You must download MySQL Shell 8.3 or above. A credentials file needs to be created on the EC2 instance to store access keys. The credentials file will be used by MySQL Shell for authentication to export data from Amazon RDS MySQL to the AWS S3 bucket.]
Download MySQL Shell: https://dev.mysql.com/downloads/shell/
Install MySQL Shell: https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-install.html
AWS
AWS Credentials File: https://docs.aws.amazon.com/cli/latest/userguide/cli-authentication-user.html#cli-authentication-user-configure-csv.titlecli-authentication-user-configure-file

V) Connect to Amazon RDS MySQL using MySQL Shell on EC2. Afterwards, execute the MySQL Shell `util.dumpInstance()` utility to export all schemas (including users, indexes, routines, triggers) from Amazon RDS MySQL to the AWS S3 bucket.

[The dump created by MySQL Shell's instance dump utility comprises DDL files specifying the schema structure, and tab-separated `.tsv` files containing the data.]
MySQL Shell Dump Utilities: https://dev.mysql.com/doc/mysql-shell/8.3/en/mysql-shell-utilities-dump-instance-schema.html

VI) Create a HeatWave MySQL on AWS DB System and a HeatWave Cluster.

[HeatWave MySQL on AWS is a fully-managed MySQL service, developed and supported by the MySQL team at Oracle.]
Provision HeatWave MySQL on AWS: https://dev.mysql.com/doc/heatwave-aws/en/heatwave-aws-dbsystem-create.html

VII) Import data from AWS S3 bucket to HeatWave MySQL on AWS.

[The data will be imported using the Data Import Feature. This feature allows you to import data in a variety of formats such as MySQL dump files and text files from an AWS S3 bucket to HeatWave MySQL on AWS in the same region.]
Importing Data Using the Data Import Feature: https://dev.mysql.com/doc/heatwave-aws/en/heatwave-aws-importing-data-data-import.html

VIII) (Optional) Use the Query Editor tab to verify whether the data was migrated successfully from Amazon RDS MySQL to HeatWave MySQL on AWS.

[The Query Editor under the Workspaces page allows you to connect to HeatWave MySQL on AWS DB System and run queries against it.]
HeatWave MySQL on AWS Console Overview: https://dev.mysql.com/doc/heatwave-aws/en/console-overview.html

IX) If the HeatWave option was enabled during HeatWave MySQL on AWS DB System creation, load data from MySQL InnoDB storage into the HeatWave Cluster using automation.

[Loading data into the HeatWave in-memory Cluster combines transactions, analytics, and machine learning services into one MySQL Database.]
Loading Data into HeatWave: https://dev.mysql.com/doc/heatwave-aws/en/heatwave-aws-loading-unloading-heatwave.html

Walkthrough:

I) Have an Oracle Cloud Infrastructure (OCI) and Amazon Web Services (AWS) account.

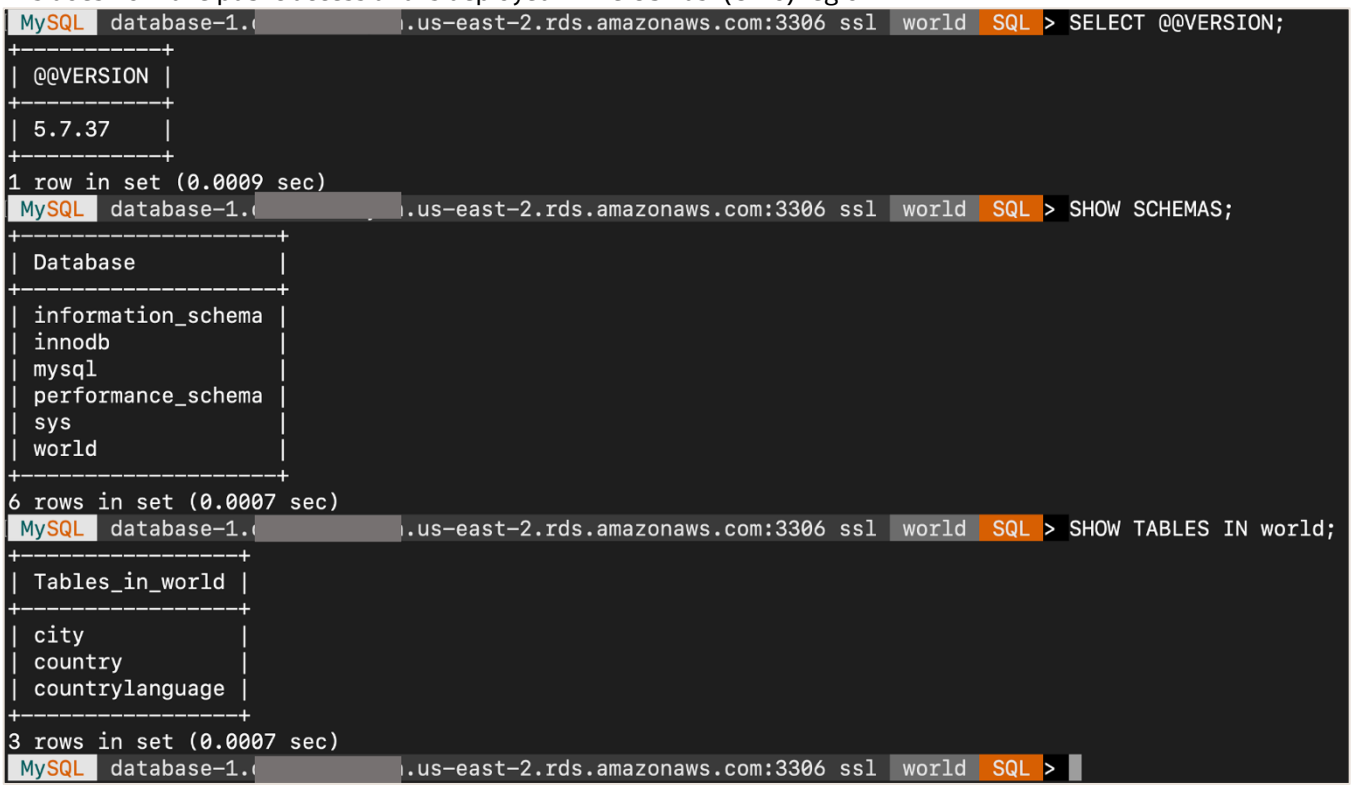
OCI Sign in/Sign up page: https://cloud.oracle.com
AWS Sign in/Sign up page: https://aws.amazon.com

II) Ensure you can access the HeatWave MySQL on AWS Console after enabling the HeatWave MySQL on AWS service on OCI.

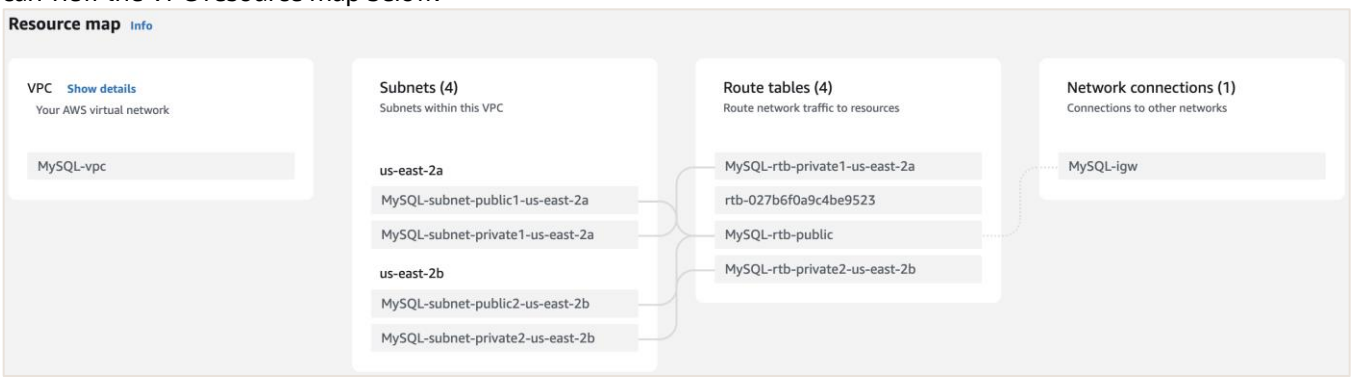
Enabling HeatWave MySQL on AWS service: https://dev.mysql.com/doc/heatwave-aws/en/heatwave-aws-getting-started.html
HeatWave MySQL on AWS Console: https://cloud.mysql.com/

III) On AWS, create an access key and an S3 bucket.

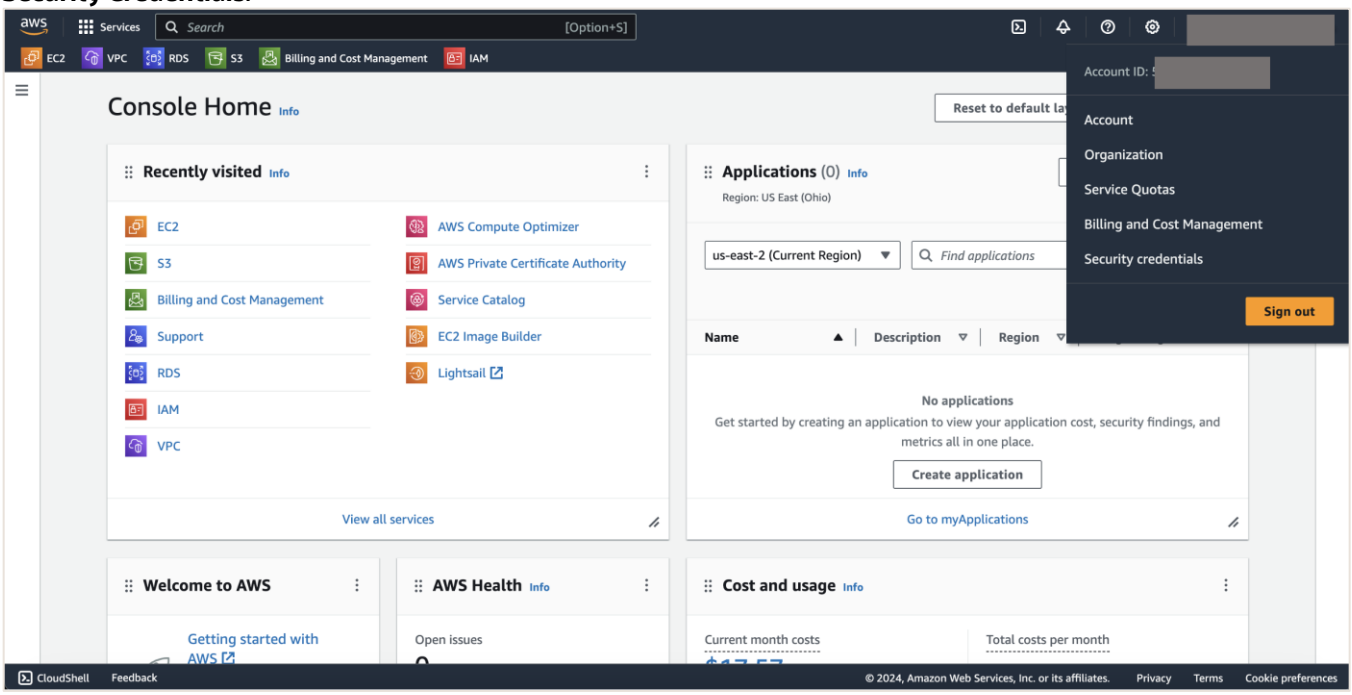
1. Below is the Amazon RDS MySQL instance version and the sample database ("world") that will be migrated for this guide. The sample world database consists of 3 tables. The Amazon RDS MySQL instance used for this does not have public access and is deployed in the US East (Ohio) region.



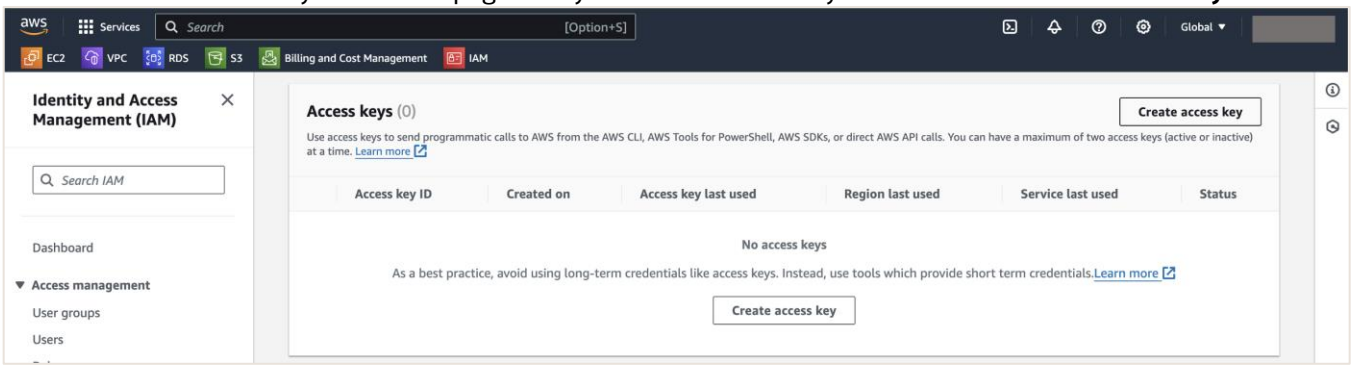
2. The AWS VPC associated with the above Amazon RDS MySQL instance uses an IPv4 CIDR: 10.1.0.0/16. You can view the VPC resource map below:



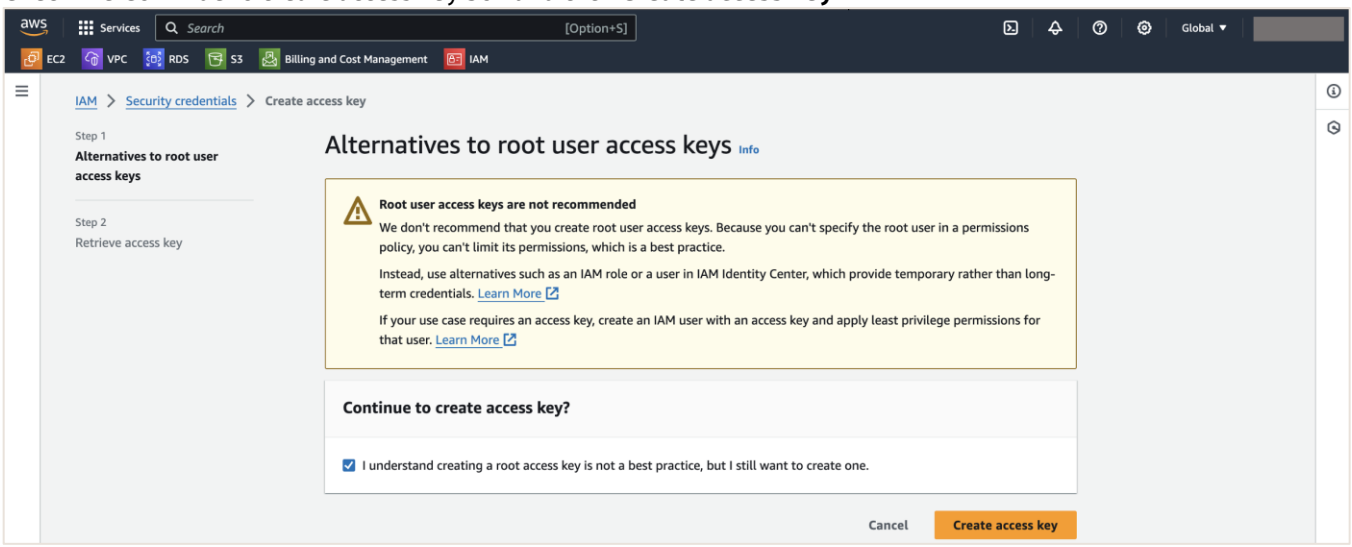
3. Log in to AWS as a root user or another user that has the AmazonS3FullAccess permissions policy and create an access key. Click on your account name or number in the upper right corner of the Console and choose **Security Credentials**.



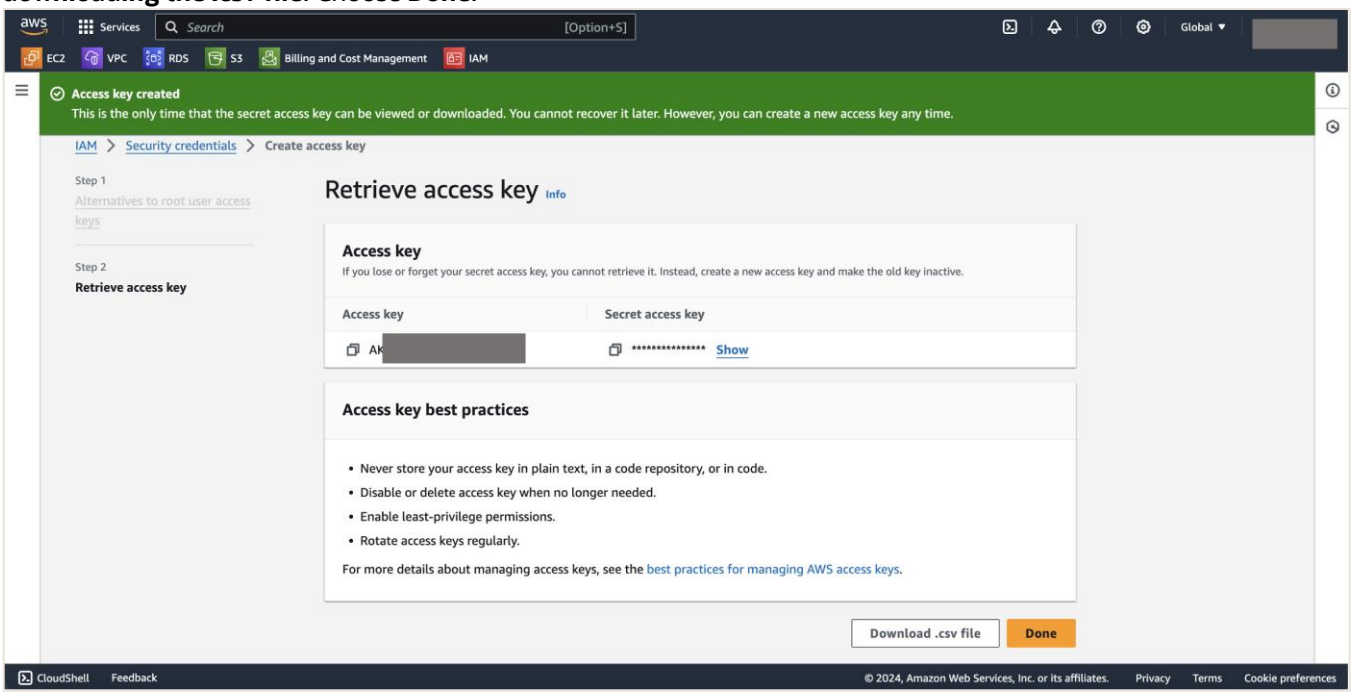
4. Scroll down on the Security Credentials page until you see the Access Keys section. Click **Create access key**.



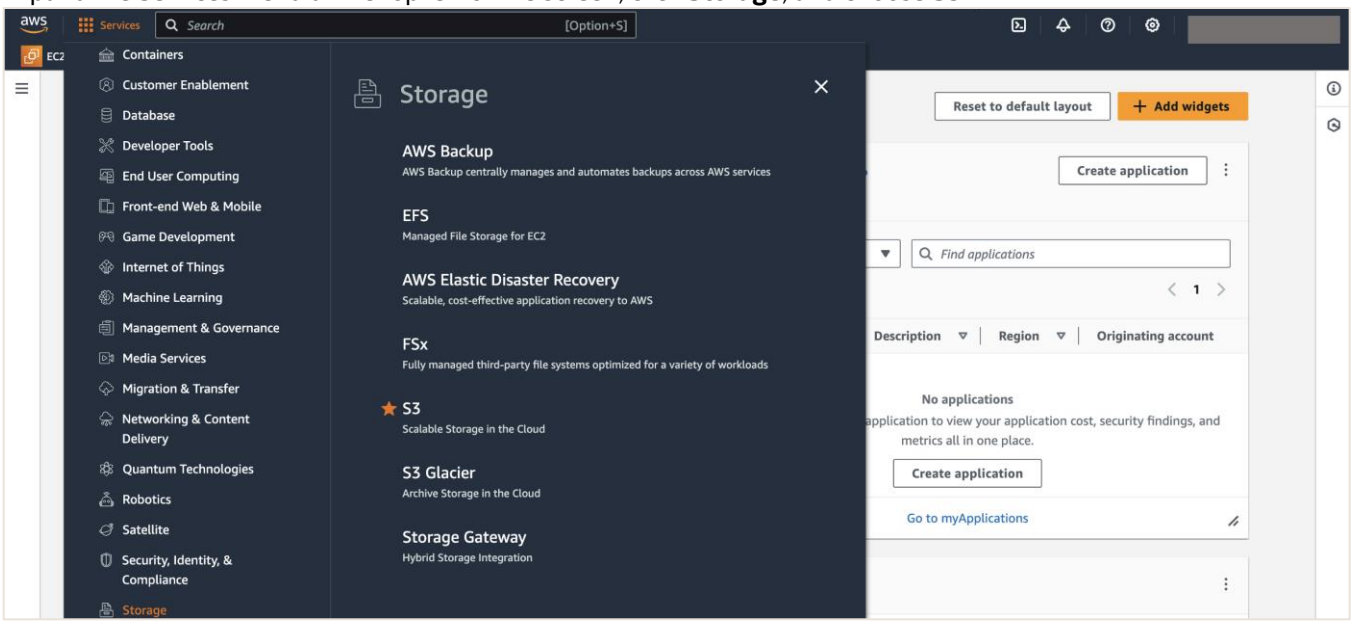
5. Check the Continue to create access key box and click **Create access key**.



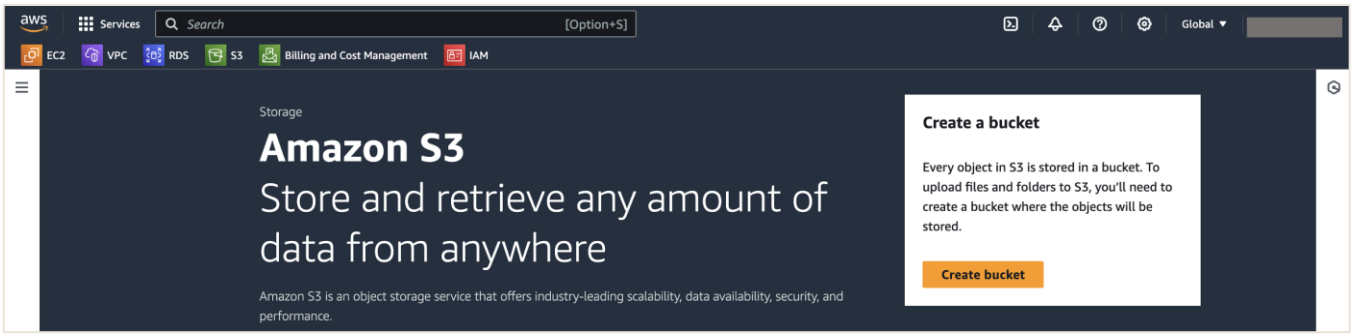
6. On the Retrieve access key page, **save the access key and secret access key values** for later use by **downloading the .csv file**. Choose **Done**.



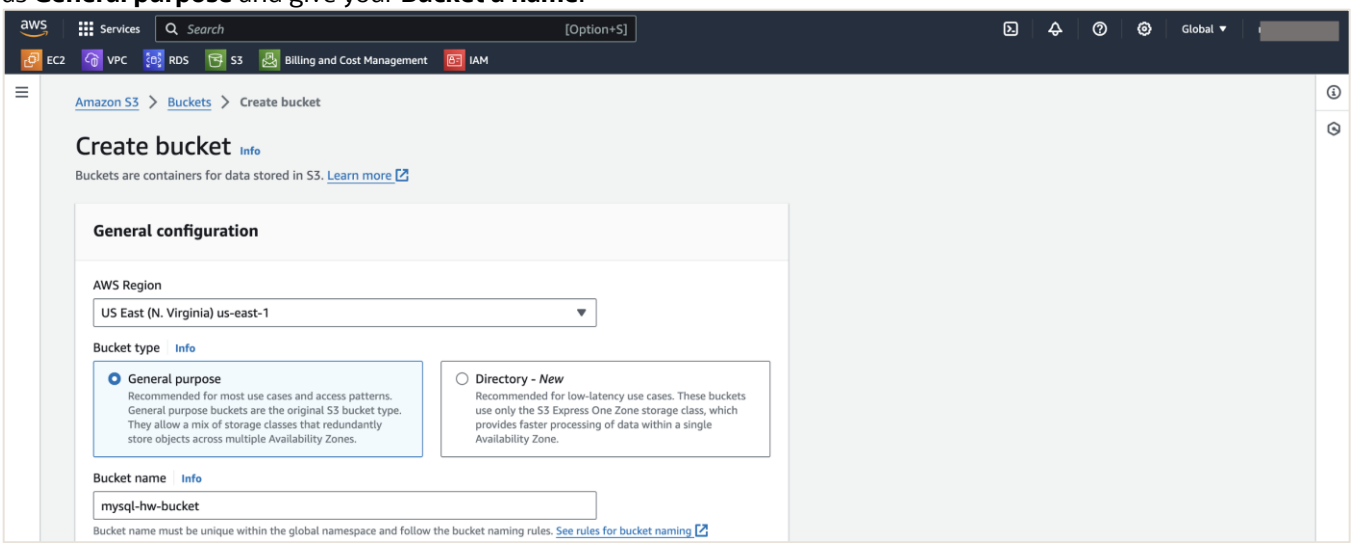
7. Expand the Services menu at the top left of the screen, click **Storage**, and choose **S3**.



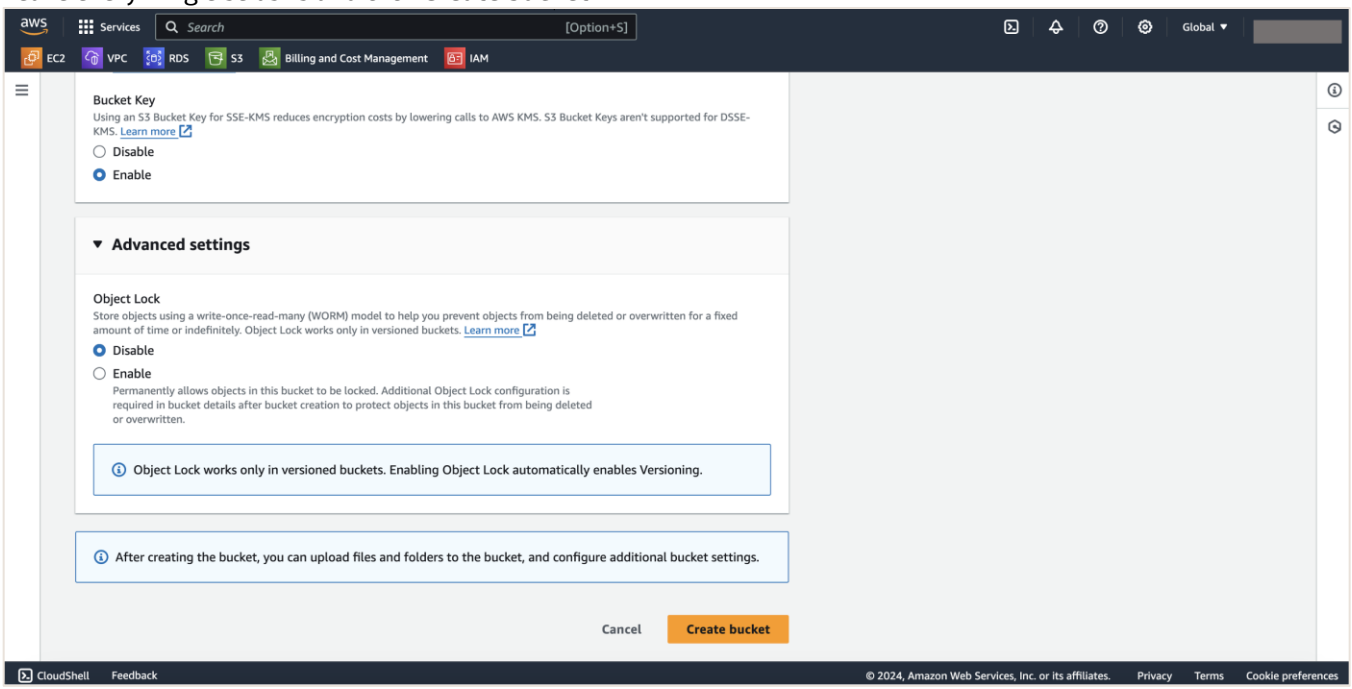
8. Click **Create bucket**.



9. **Select the AWS Region** where you want to create the bucket. The bucket must be in the same region as HeatWave MySQL on AWS. For this guide, we are going to deploy the bucket in US East (N. Virginia) as that is where we will deploy the HeatWave MySQL on AWS DB System later in this section. Choose the **Bucket type** as **General purpose** and give your **Bucket a name**.

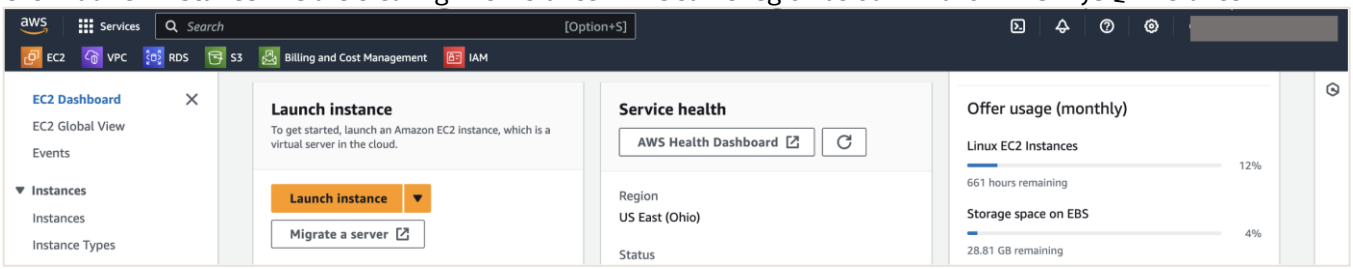


10. Leave everything else as-is and click **Create bucket**.

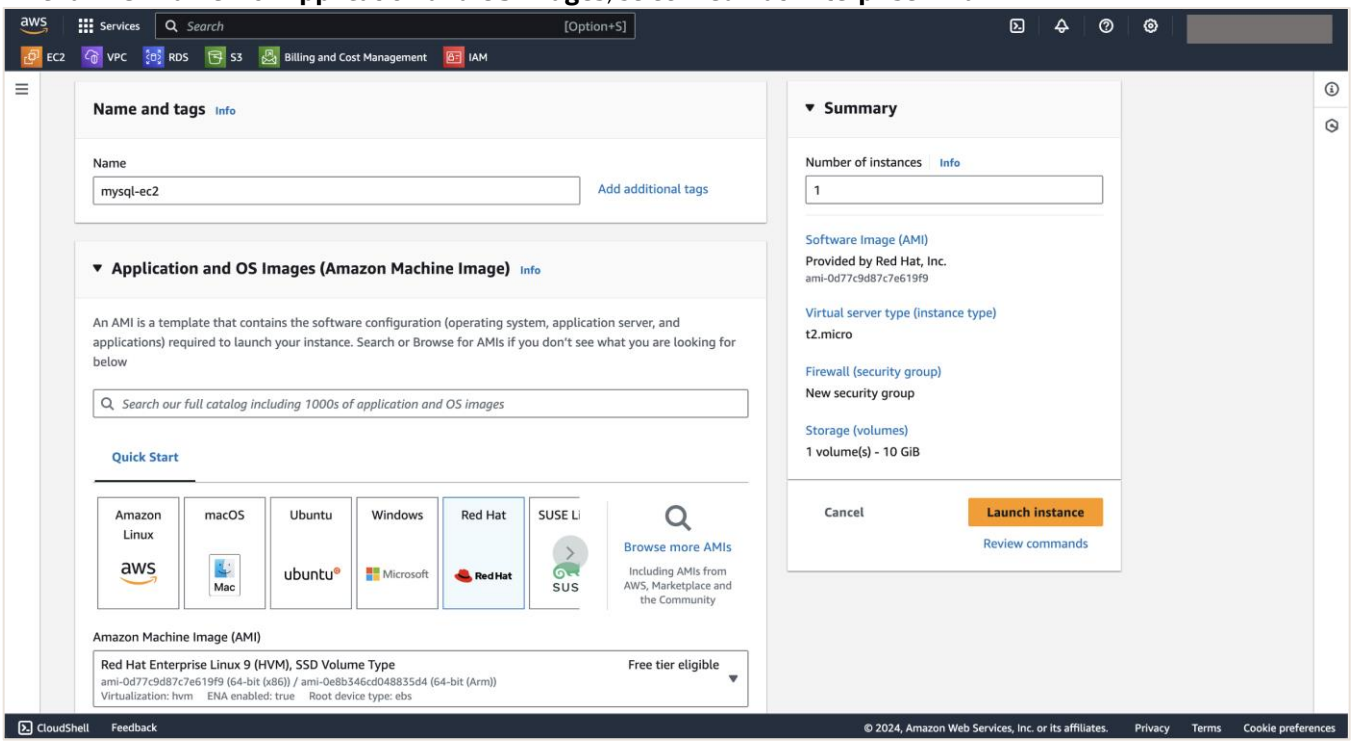


IV) Install MySQL Shell 8.3 (or above) on an EC2 instance that can connect to Amazon RDS MySQL and create a credentials file.

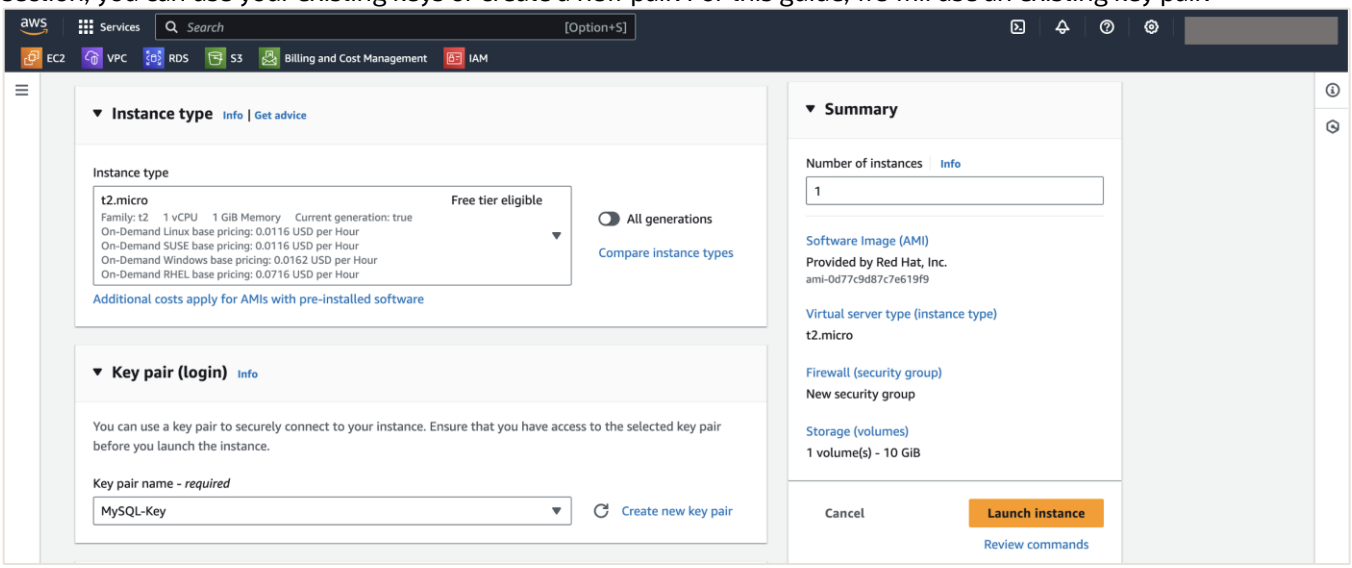
11. From the AWS Services menu, go to **Compute** and select **EC2**.
12. Click **Launch instance**. We are creating this instance in the same region as our Amazon RDS MySQL instance.



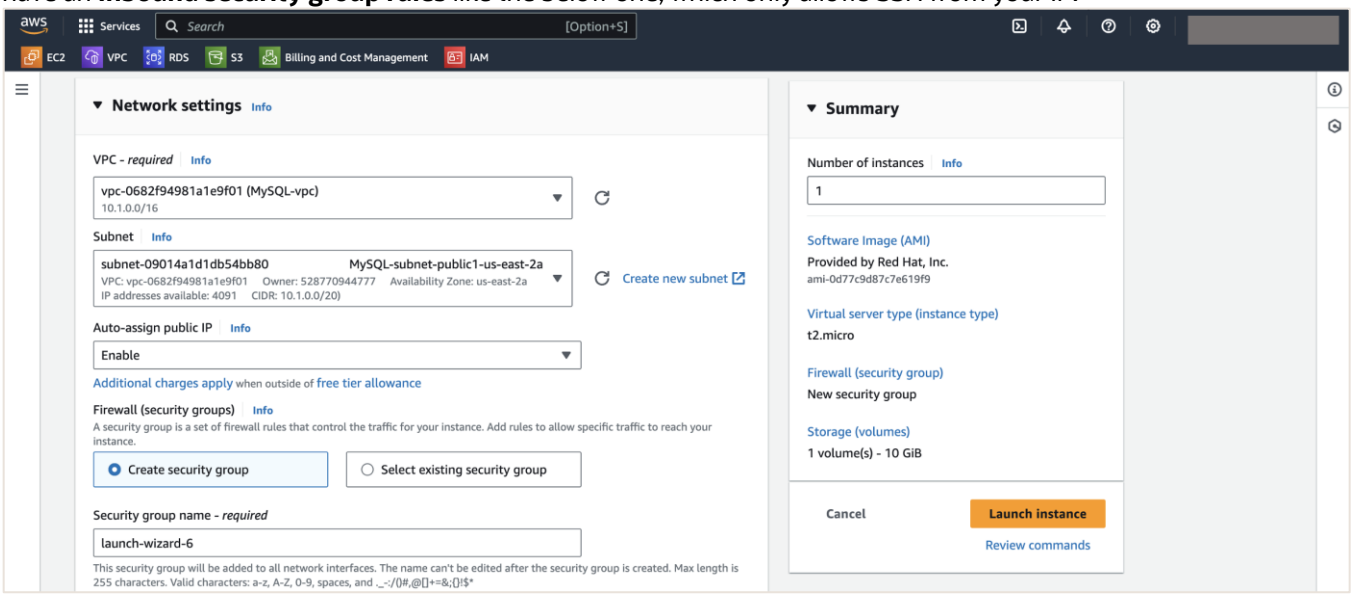
13. Enter an **EC2 name**. For **Application and OS Images**, select **Red Hat Enterprise Linux 9**.

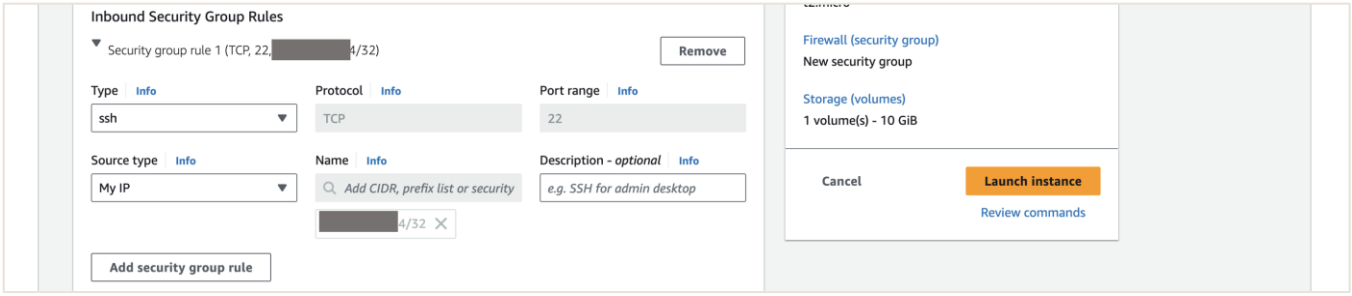


14. For **Instance type**, choose an instance type you think is appropriate. If you have large amounts of data - provisioning an EC2 with more vCPUs and Memory will speed up the migration process. For the **Key pair** section, you can use your existing keys or create a new pair. For this guide, we will use an existing key pair.

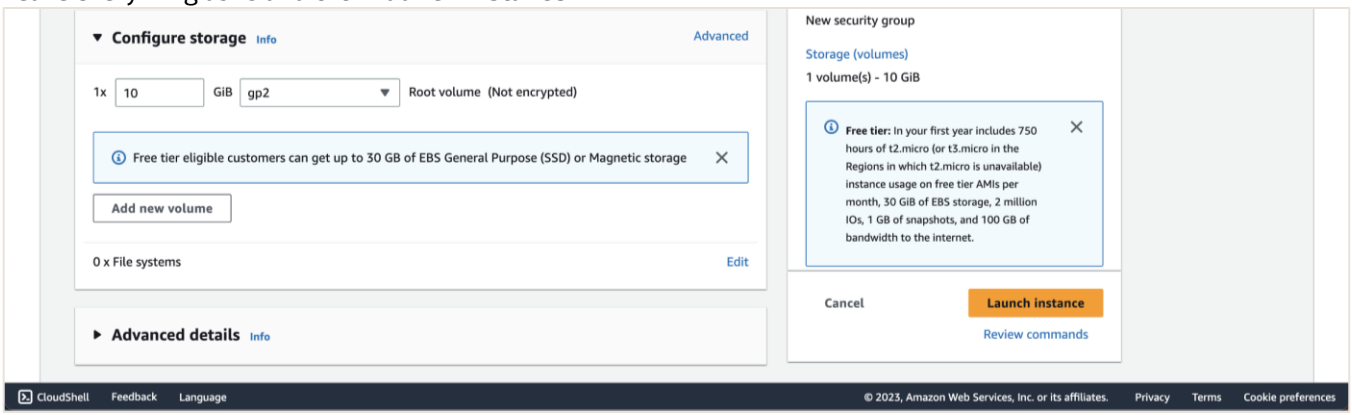


15. Under Network settings, ensure that the correct **VPC** (the VPC that is associated with your RDS instance) and **Subnet** are selected. For this guide - we have decided to deploy the EC2 inside a public subnet. For **Auto-assign public IP** select **Enable**. Under the **Firewall (security groups)**, choose **Create security group** and have an **Inbound security group rules** like the below one, which only allows SSH from your IP.

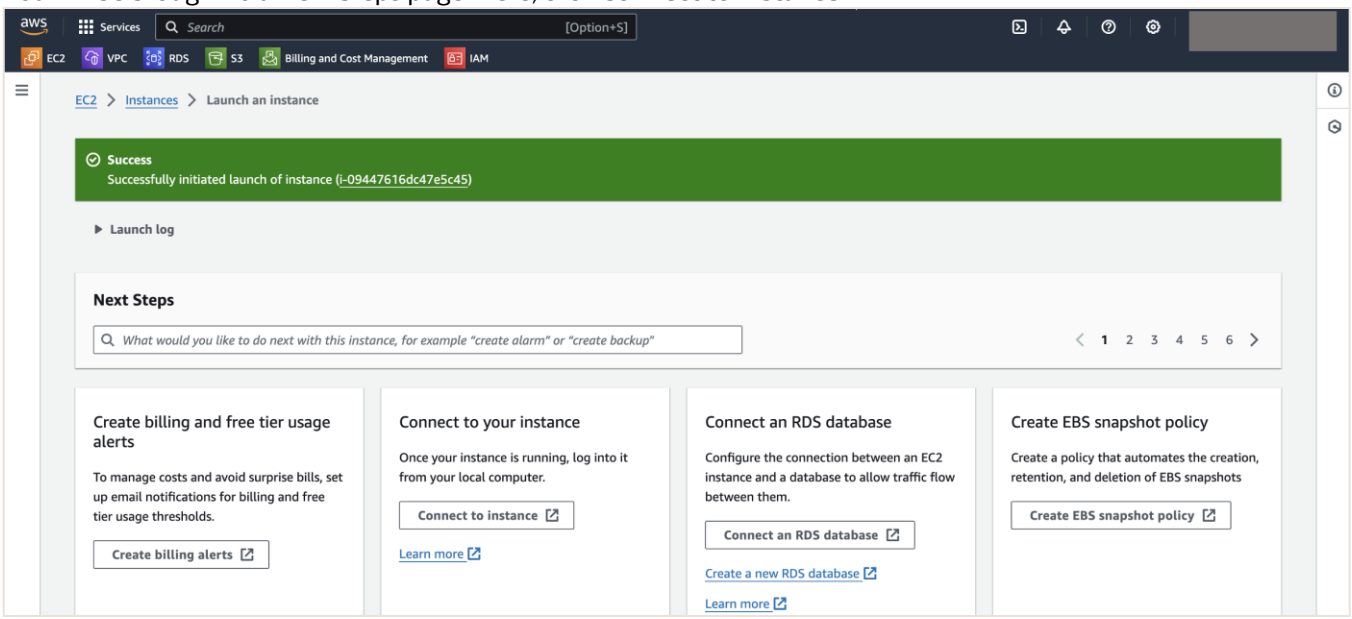




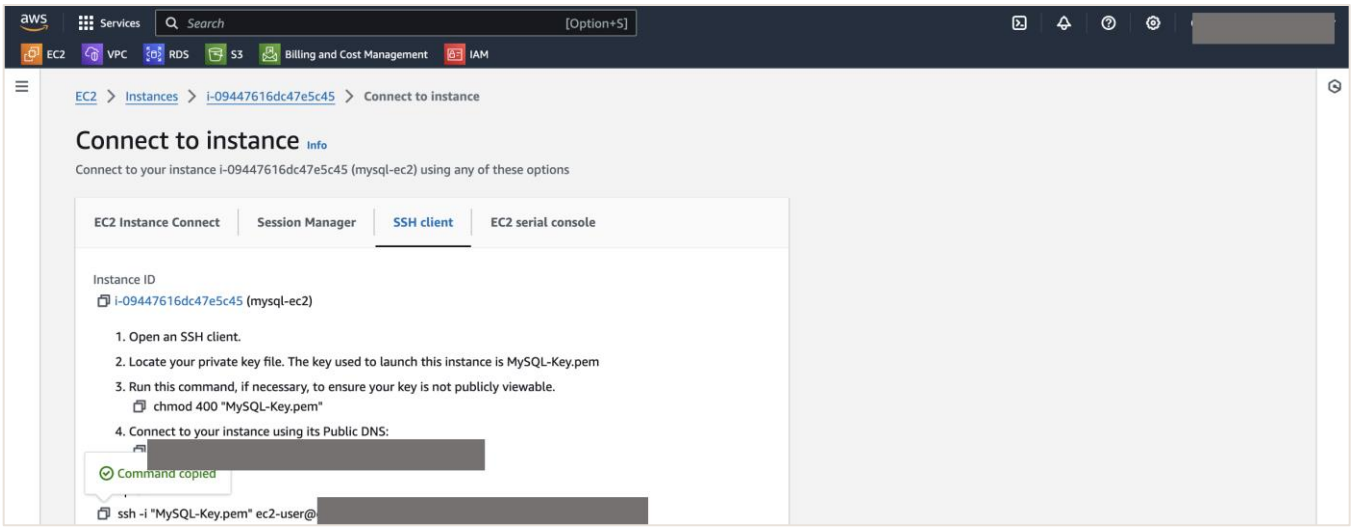
16. Leave everything as-is and click **Launch instance**.



17. You will be brought to a Next Steps page. Here, click **Connect to instance**.



18. If you are using the SSH client to connect to EC2, copy the **Example** SSH command and log in to your EC2 instance.



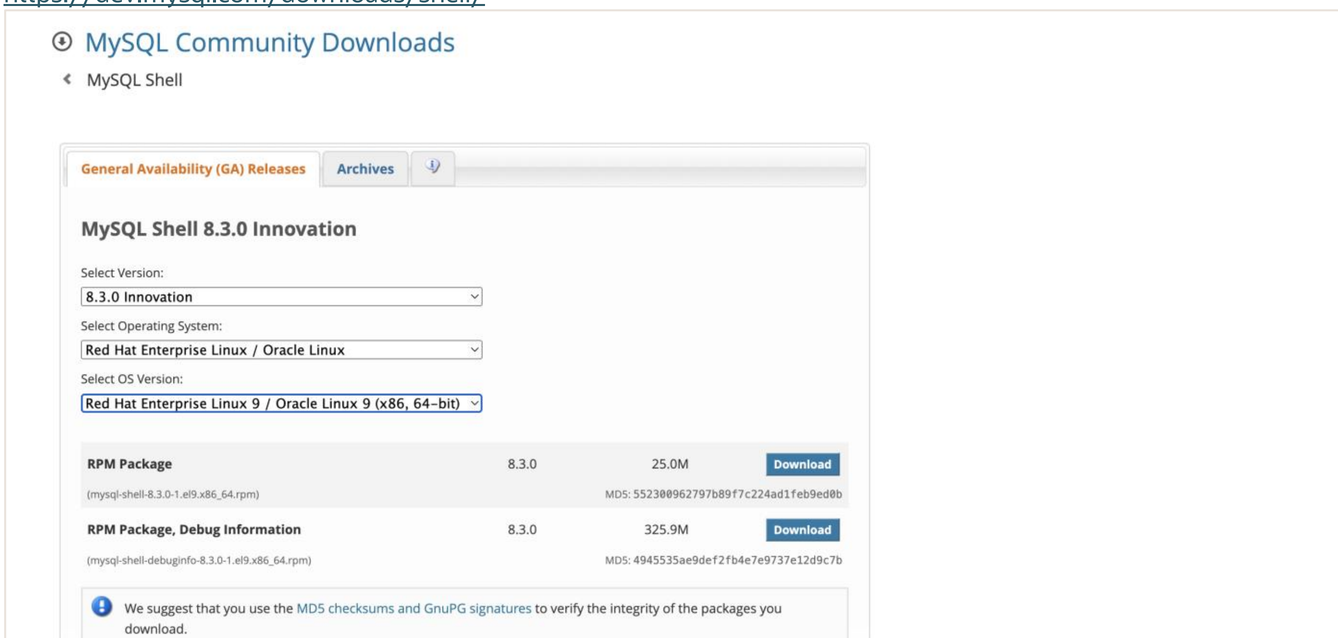
19. You can SSH into EC2 using the below command:

```
$ ssh -i </path/to/private-ssh-key> ec2-user@<ec2-Public-DNS>
```

Note: after running the above SSH command, if prompted **Are you sure you want to continue connecting (yes/no/[fingerprint])?**, type **yes**.

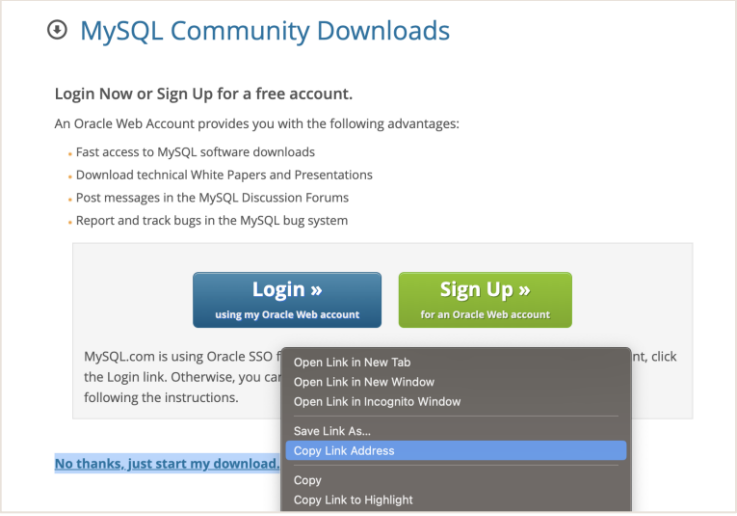
20. We are now successfully connected to the EC2 instance.

21. After making a connection to the EC2 instance, go to the below website and download MySQL Shell 8.3 on your EC2 instance. From the MySQL Shell download page, under **Select Version**, ensure **8.3.x Innovation or higher** is selected. MySQL Shell 8.3 is fully compatible with MySQL 8.3, 8.2, 8.1, 8.0, and 5.7. For **Operating System** and **OS Version** - pick the appropriate option depending on the OS and the OS Version that you are running. Click **Download**. Do not download the Debug Information Package.
https://dev.mysql.com/downloads/shell/



Note: for this guide, we will show you how to install MySQL Shell on a Linux environment. For other environments, see Installing MySQL Shell on Windows, Installing MySQL Shell on Linux, and Installing MySQL Shell on macOS.

22. Right-click on **No thanks, just start my download** and click **Copy link address**.



23. Go back to the EC2 instance that can connect to your Amazon RDS MySQL and execute the below command to download MySQL Shell:

```
$ wget <MySQL-Shell-Download-Link>
```

Replace the link with what you have.

```
$ wget https://dev.mysql.com/get/Downloads/MySQL-Shell/mysql-shell-8.3.0-1.el9.x86_64.rpm
```

```
[ec2-user@ip-10-1-6-184 ~]$ wget https://dev.mysql.com/get/Downloads/MySQL-Shell/mysql-shell-8.3.0-1.el9.x86_64.rpm
--2024-02-23 15:40:43--  https://dev.mysql.com/get/Downloads/MySQL-Shell/mysql-shell-8.3.0-1.el9.x86_64.rpm
Resolving dev.mysql.com (dev.mysql.com)... 23.61.106.232, 2600:141f:4000:494::2e31, 2600:141f:4000:48a::2e31
Connecting to dev.mysql.com (dev.mysql.com)|23.61.106.232|:443... connected.
HTTP request sent, awaiting response... 302 Moved Temporarily
Location: https://cdn.mysql.com//Downloads/MySQL-Shell/mysql-shell-8.3.0-1.el9.x86_64.rpm [following]
--2024-02-23 15:40:44--  https://cdn.mysql.com//Downloads/MySQL-Shell/mysql-shell-8.3.0-1.el9.x86_64.rpm
Resolving cdn.mysql.com (cdn.mysql.com)... 23.61.42.21, 2600:141f:4000:4a2::1d68, 2600:141f:4000:48b::1d68
Connecting to cdn.mysql.com (cdn.mysql.com)|23.61.42.21|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 26212068 (25M) [application/x-redhat-package-manager]
Saving to: 'mysql-shell-8.3.0-1.el9.x86_64.rpm'

mysql-shell-8.3.0-1.el 100%[=========================>]  25.00M  23.2MB/s    in 1.1s

2024-02-23 15:40:46 (23.2 MB/s) - 'mysql-shell-8.3.0-1.el9.x86_64.rpm' saved [26212068/26212068]
```

Note: to install `wget` on the EC2, execute:

```
$ sudo yum install wget
```

24. After downloading the MySQL Shell rpm, install MySQL Shell:

```
$ sudo yum localinstall mysql-shell*
```

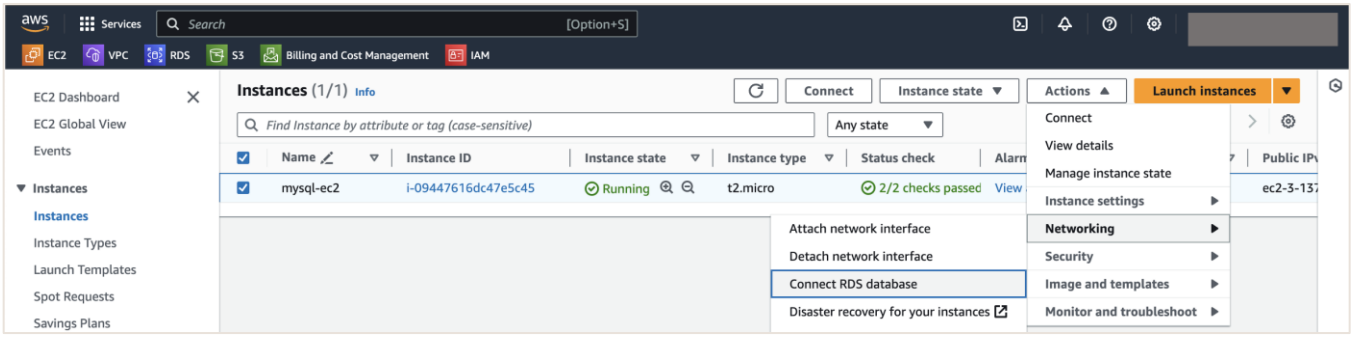
```
[ec2-user@ip-10-1-6-184 ~]$ sudo yum localinstall mysql-shell*
Updating Subscription Management repositories.
Unable to read consumer identity

This system is not registered with an entitlement server. You can use subscription-manage
r to register.

Last metadata expiration check: 0:00:55 ago on Fri 23 Feb 2024 03:40:29 PM UTC.
Dependencies resolved.
================================================================================
 Package              Architecture    Version                 Repository          Size
================================================================================
Installing:
 mysql-shell          x86_64          8.3.0-1.el9             @commandline        25 M

Transaction Summary
================================================================================
Install  1 Package
```

25. You can now verify if MySQL Shell has successfully installed on your EC2 instance by executing the below command:

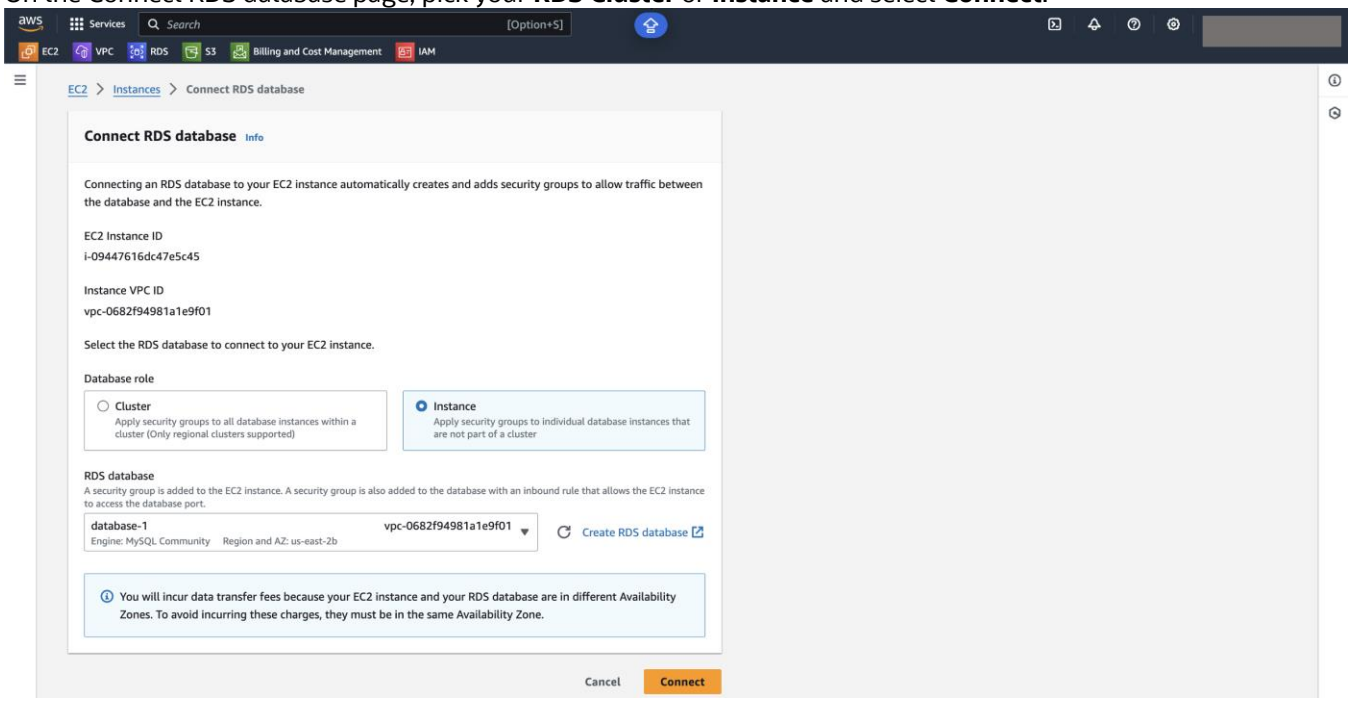
```
$ mysqlsh --version
```

```
[ec2-user@ip-10-1-6-184 ~]$ mysqlsh --version
mysqlsh   Ver 8.3.0 for Linux on x86_64 - for MySQL 8.3.0 (MySQL Community Server (GPL))
```

26. Go back to the AWS EC2 Instances page and **select your EC2 instance**. Choose **Actions**, then **Networking**, and **click Connect RDS database**.



27. On the Connect RDS database page, pick your **RDS Cluster** or **Instance** and select **Connect**.



28. Next, **log in to your Amazon RDS MySQL using MySQL Shell** by executing the below command:

```
$ mysqlsh <user>@<hostname>:<port-number>
```

-OR-

```
$ mysqlsh -u <user> -p -h <hostname> -P <port-number>
```

```
[ec2-user@ip-10-1-6-184 ~]$ mysqlsh admin@database-1.          .us-east-2.rds.amazonaws
.com
Please provide the password for 'admin@database-1.          .us-east-2.rds.amazonaws.co
m': ********
Save password for 'admin@database-1.          .us-east-2.rds.amazonaws.com'? [Y]es/[N]o
/Ne[v]er (default No): y
MySQL Shell 8.3.0

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Oracle is a registered trademark of Oracle Corporation and/or its affiliates.
Other names may be trademarks of their respective owners.

Type '\help' or '\?' for help; '\quit' to exit.
Creating a session to 'admin@database-1.          .us-east-2.rds.amazonaws.com'
Fetching schema names for auto-completion... Press ^C to stop.
Your MySQL connection id is 18
Server version: 5.7.37-log Source distribution
No default schema selected; type \use <schema> to set one.
 MySQL  database-1.          .us-east-2.rds.amazonaws  JS >
```

Note: you can interact with MySQL Shell using JavaScript, Python, or SQL mode. The default is JavaScript. To switch between the different modes, execute `/js` for JavaScript, `/py` for Python, and `/sql` for SQL mode inside MySQL Shell. To exit out of MySQL Shell, execute `/q`.

29. Exit out of MySQL Shell and **create a `.aws` directory** inside the home directory of your EC2 instance. Go inside the newly created directory and **create a file called `credentials`** using the text editor of your choice.

```
MySQL JS> \q
$ mkdir ~/.aws
$ cd .aws
$ nano credentials
```

30. Inside the credentials file, **paste the below contents** and fill in the `aws_access_key_id` and `aws_secret_access_key` values using the .csv file you downloaded in step 6.

```
[default]
aws_access_key_id =
aws_secret_access_key =
```

31. Save and close the file.

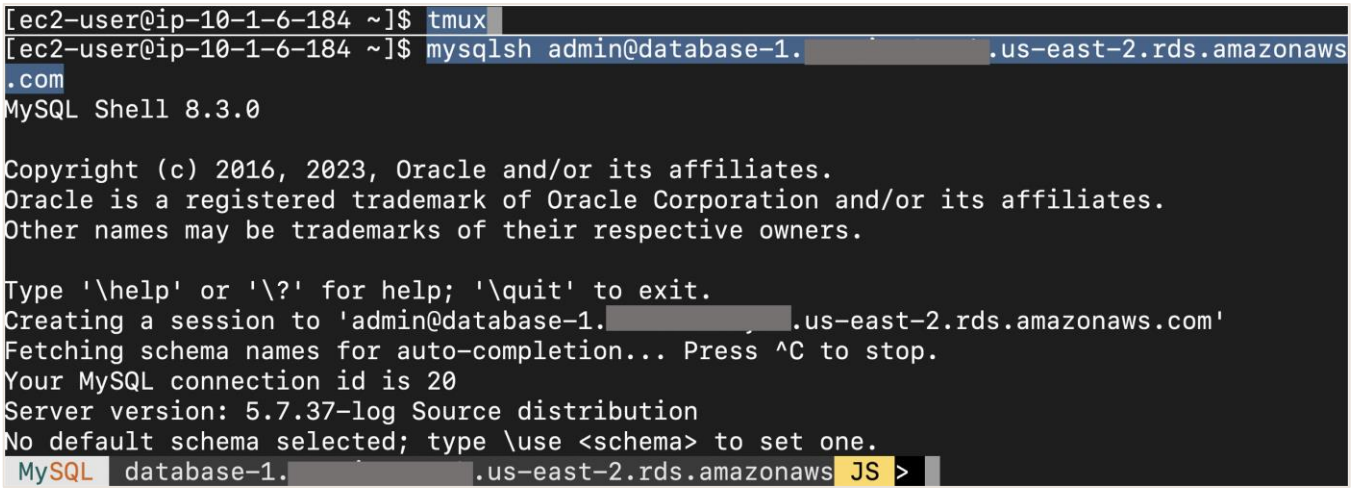
V) Connect to Amazon RDS MySQL using MySQL Shell on EC2. Afterwards, execute the MySQL Shell `util.dumpInstance()` utility to export all schemas (including users, indexes, routines, triggers) from Amazon RDS MySQL to the AWS S3 bucket.

32. Before connecting to Amazon RDS MySQL using MySQL Shell and proceeding with the below steps, it is highly recommended that you use a command like **screen** or **tmux**. These commands will allow you to reconnect to a dropped session in case your connection drops in the middle of performing the MySQL Shell export using `util.dumpInstance()`. For small databases, the screen or tmux may not be necessary. For this guide, we will use tmux. To learn more about tmux, see A beginner's guide to tmux. Below are the basics of using the tmux command:
    - Install tmux on Linux: `$ sudo yum install tmux`
    - Start a new tmux session, from your terminal execute: `$ tmux`
    - List all the active tmux sessions: `$ tmux ls`
    - Detach from a tmux session and leave it running in the background: `$ Ctrl+B d`
    - Attach a tmux session running in the background: `$ tmux attach`
    - End a tmux session: `$ Ctrl+B &`
33. Start a tmux session and connect to your Amazon RDS MySQL using MySQL Shell on EC2.

    ```
    $ tmux
    $ mysqlsh <user>@<hostname>:<port-number>
    ```

    -OR-

    ```
    $ mysqlsh -u <user> -p -h <hostname> -P <port-number>
    ```



34. Change to the JavaScript mode (if you are not in JS mode) of MySQL Shell and run the `util.dumpInstance()` utility to export all Amazon RDS MySQL data into the S3 bucket. The data will be copied over from Amazon RDS MySQL to S3 using HTTPS.

```
MySQL JS> \js
MySQL JS> util.dumpInstance("mysql-hw-dump",{s3bucketName: "mysql-hw-bucket",
"compatibility": ["force_innodb", "skip_invalid_accounts", "strip_definers",
"strip_restricted_grants", "strip_tablespaces", "ignore_wildcard_grants",
"strip_invalid_grants", "create_invisible_pks"], users: "true", threads: 4,
targetVersion: "8.3.0", ocimds: "true", dryRun:"true"})
```

Note: replace the bucket name (`mysql-hw-bucket`) with your S3 bucket name and the target version (`8.3.0`) to the HeatWave MySQL on AWS version that you are planning to migrate to.

```
 MySQL  database-1.                .us-east-2.rds.amazonaws  JS > util.dumpInstance("mysql-hw
-dump",{s3bucketName: "mysql-hw-bucket", "compatibility": ["force_innodb", "skip_invalid
_accounts", "strip_definers", "strip_restricted_grants", "strip_tablespaces", "ignore_wi
ldcard_grants", "strip_invalid_grants", "create_invisible_pks"], users: "true", threads:
 4, targetVersion: "8.3.0", ocimds: "true", dryRun:"true"})
NOTE: The 'targetVersion' option is set to 8.3.0. This version supports the SET_ANY_DEFI
NER privilege, using the 'strip_definers' compatibility option is unnecessary.
dryRun enabled, no locks will be acquired and no files will be created.
NOTE: Backup lock is not supported in MySQL 5.7 and DDL changes will not be blocked. The
 dump may fail with an error if schema changes are made while dumping.
Acquiring global read lock
WARNING: The current user lacks privileges to acquire a global read lock using 'FLUSH TA
BLES WITH READ LOCK'. Falling back to LOCK TABLES...
Table locks acquired
Initializing - done
2 out of 6 schemas will be dumped and within them 3 tables, 0 views.
2 out of 4 users will be dumped.
```

[... output truncated]

```
Writing DDL - done
Starting data dump
0% (0 rows / ~5.27K rows), 0.00 rows/s, 0.00 B/s uncompressed, 0.00 B/s compressed
 MySQL  database-1.                .us-east-2.rds.amazonaws  JS >
```

Note:

- `util.dumpInstance(outputUrl[, options])`: MySQL instance dump utility exports all schemas or a selected schema from a MySQL instance into a set of local files or an OCI or AWS bucket. By default, this utility includes all schemas, users, indexes, routines, and triggers. You can use the `excludeSchemas` or `includeSchemas` and `excludeTables` or `includeTables` option to specify individual schemas or tables to be excluded or included in the dump files. For example: `excludeSchemas: ["test", "world"]` and `excludeTables: ["test.table", ["world.city"]`. See Dump Utilities.
- `s3BucketName`: The name of the S3 bucket to which the dump is to be written.
- `compatibility`: Apply the specified requirements for compatibility with HeatWave MySQL for all tables in the dump output, altering the dump files as necessary.
    - `force_innodb`: Change `CREATE TABLE` statements to use the InnoDB storage engine for any tables that do not already use it.

    - `skip_invalid_accounts`: You cannot export a user that has no password defined. This option skips any such users.
    - `strip_definers`: Remove the `DEFINER` clause from views, routines, events, and triggers, so these objects are created with the default definer (the user invoking the schema) and change the `SQL SECURITY` clause for views and routines to specify `INVOKER` instead of `DEFINER`. HeatWave MySQL requires special privileges to create these objects with a definer other than the user loading the schema. If your security model requires that views and routines have more privileges than the account querying or calling them, you must manually modify the schema before loading it. If you plan to use HeatWave MySQL on AWS v8.3 or above, this option is not required.
    - `strip_restricted_grants`: Certain privileges are restricted in HeatWave MySQL. Privileges such as `RELOAD`, `FILE`, `SUPER`, `BINLOG_ADMIN`, and `SET_USER_ID`. You cannot create users granting these privileges. This option strips these privileges from dumped `GRANT` statements.
    - `strip_tablespaces`: Tablespaces have some restrictions in HeatWave MySQL. If you need tables created in their default tablespaces, this option strips the `TABLESPACE=` option from `CREATE TABLE` statements.
    - `ignore_wildcard_grants`: If enabled, ignores errors from grants on schemas with wildcards, which are interpreted differently in systems where the partial_revokes system variable is enabled.
    - `strip_invalid_grants`: If enabled, strips grant statements which would fail when users are copied, such as grants referring to a specific routine which does not exist.
    - `create_invisible_pks`: Primary keys are required by High Availability and HeatWave. If you intend to export data for use in a highly available DB system or a HeatWave DB system, add primary keys as they are not defined on the tables. This compatibility flag adds invisible primary keys to each table that requires them.
- `users`: Include (`true`) or exclude (`false`) users and their roles and grants in the dump. You can use the `excludeUsers` or `includeUsers` option to specify individual user accounts to be excluded or included in the dump files. For example: `excludeUsers: ["'test'@'%'", "'root'@'localhost'"]`.
- `threads`: (Optional) The number of parallel threads to use to dump chunks of data from the MySQL instance. Each thread has its own connection to the MySQL instance. The default is 4.
- `targetVersion`: Define the version of the target MySQL instance, in n.n.n format. Such as 8.3.0 or 8.0.36, for example. If the value is not set, the MySQL Shell version is used.
- `ocimds`: Setting this option to `true` enables checks and modifications for compatibility with the HeatWave MySQL Service.
- `dryRun`: Displays information about the copy with the specified set of options, and about the results of HeatWave MySQL Service compatibility checks but does not proceed with the copy. Setting this option enables you to list out all the compatibility issues before starting the copy.
- `consistent`: Enable (`true`) or disable (`false`) consistent data copies by locking the instance for backup during the copy.

35. Running the above step 34 command may generate **Errors** regarding **table locks** (see image below). If you do encounter such a problem (if and only if) run the same command as in step 34 but this time add an additional option: `consistent: "false"` and re-run the command.

```
MySQL JS> util.dumpInstance("mysql-hw-dump",{s3bucketName: "mysql-hw-bucket",
"compatibility": ["force_innodb", "skip_invalid_accounts", "strip_definers",
"strip_restricted_grants", "strip_tablespaces", "ignore_wildcard_grants",
"strip_invalid_grants", "create_invisible_pks"], users: "true", threads: 4,
targetVersion: "8.3.0", ocimds: "true", dryRun:"true", consistent: "false"})
```

Note: replace the bucket name (`mysql-hw-bucket`) with your S3 bucket name and the target version (`8.3.0`) to the HeatWave MySQL on AWS version that you are planning to migrate to.

```
WARNING: SRC: The current user lacks privileges to acquire a global read lock using 'FLUSH TAB
LES WITH READ LOCK'. Falling back to LOCK TABLES...
ERROR: SRC: The current user does not have required privileges to execute FLUSH TABLES WITH RE
AD LOCK.
    Backup lock is not supported in MySQL 5.7 and DDL changes cannot be blocked.
    The gtid_mode system variable is set to OFF or OFF_PERMISSIVE.
    The log_bin system variable is set to OFF or the current user does not have required privi
leges to execute SHOW MASTER STATUS.
The consistency of the dump cannot be guaranteed.
ERROR: SRC: Unable to acquire global read lock neither table read locks.
```

```
MySQL database-1.           .us-east-2.rds.amazonaws JS > util.dumpInstance("mysql-hw
-dump",{s3bucketName: "mysql-hw-bucket", "compatibility": ["force_innodb", "skip_invalid
_accounts", "strip_definers", "strip_restricted_grants", "strip_tablespaces", "ignore_wi
ldcard_grants", "strip_invalid_grants", "create_invisible_pks"], users: "true", threads:
 4, targetVersion: "8.3.0", ocimds: "true", dryRun:"true", consistent: "false"})
```

36. Once you have run the command in step 34/35 and do not see any errors in the output (warnings are okay), run the same step 34 (or step 35 if required) command but this time change the `dryRun` option to `false`.

```
MySQL JS> util.dumpInstance("mysql-hw-dump",{s3bucketName: "mysql-hw-bucket",
"compatibility": ["force_innodb", "skip_invalid_accounts", "strip_definers",
"strip_restricted_grants", "strip_tablespaces", "ignore_wildcard_grants",
"strip_invalid_grants", "create_invisible_pks"], users: "true", threads: 4,
targetVersion: "8.3.0", ocimds: "true", dryRun:"false"})
```

Note: replace the bucket name (`mysql-hw-bucket`) with your S3 bucket name and the target version (`8.3.0`) to the HeatWave MySQL on AWS version that you are planning to migrate to. Add the `consistent: "false"` option if you have encountered the table lock error.

```
 MySQL  database-1.                .us-east-2.rds.amazonaws  JS > util.dumpInstance("mysql-hw
-dump",{s3bucketName: "mysql-hw-bucket", "compatibility": ["force_innodb", "skip_invalid
_accounts", "strip_definers", "strip_restricted_grants", "strip_tablespaces", "ignore_wi
ldcard_grants", "strip_invalid_grants", "create_invisible_pks"], users: "true", threads:
 4, targetVersion: "8.3.0", ocimds: "true", dryRun:"false"})
NOTE: The 'targetVersion' option is set to 8.3.0. This version supports the SET_ANY_DEFI
NER privilege, using the 'strip_definers' compatibility option is unnecessary.
NOTE: Backup lock is not supported in MySQL 5.7 and DDL changes will not be blocked. The
 dump may fail with an error if schema changes are made while dumping.
Acquiring global read lock
WARNING: The current user lacks privileges to acquire a global read lock using 'FLUSH TA
BLES WITH READ LOCK'. Falling back to LOCK TABLES...
Table locks acquired
Initializing - done
2 out of 6 schemas will be dumped and within them 3 tables, 0 views.
2 out of 4 users will be dumped.
```

[... output truncated]

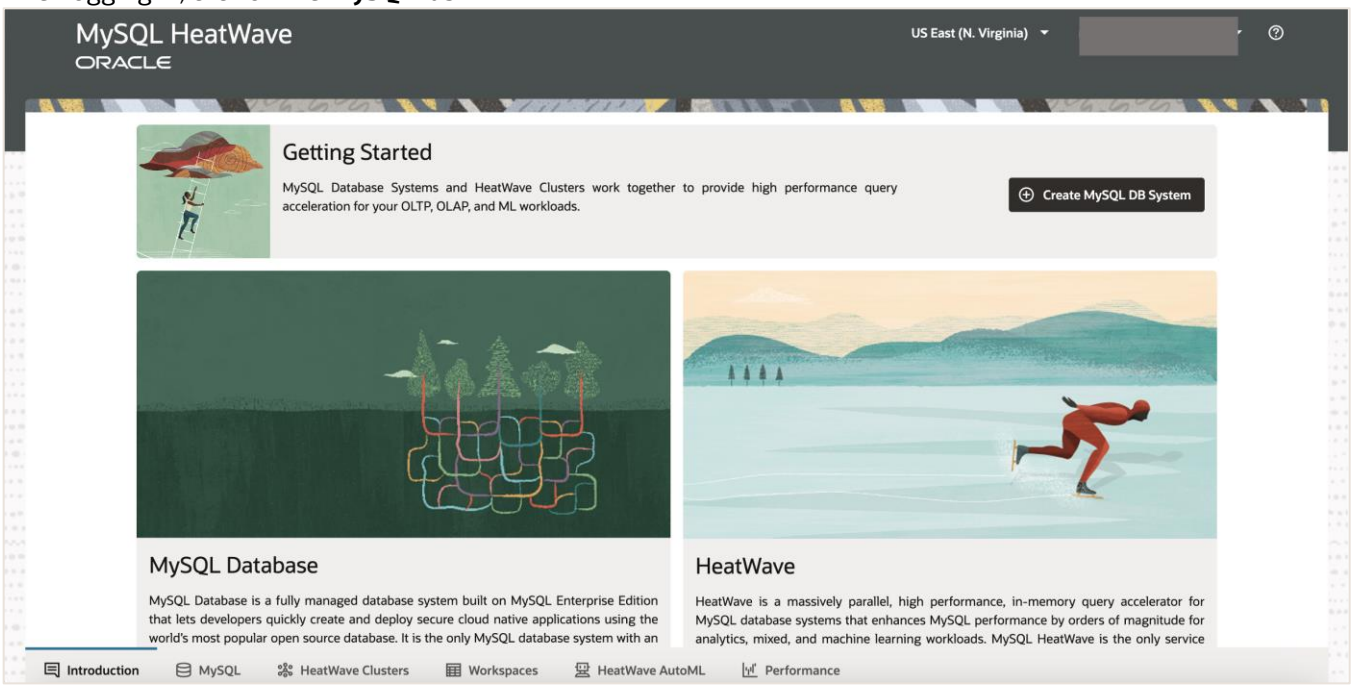
```
Writing schema metadata - done
Writing DDL - done
Writing table metadata - done
Starting data dump
2 thds dumping - 80% (4.24K rows / ~5.27K rows), 0.00 rows/s, 0.00 B/s uncompressed, 0.00 B/s

100% (5.30K rows / ~5.27K rows), 0.00 rows/s, 0.00 B/s uncompressed, 0.00 B/s compressed
Dump duration: 00:00:00s
Total duration: 00:00:01s
Schemas dumped: 2
Tables dumped: 3
Uncompressed data size: 194.61 KB
Compressed data size: 91.66 KB
Compression ratio: 2.1
Rows written: 5302
Bytes written: 91.66 KB
Average uncompressed throughput: 194.61 KB/s
Average compressed throughput: 91.66 KB/s
 MySQL  database-1.                .us-east-2.rds.amazonaws  JS >
```

Note: once the MySQL Shell dump utility finishes, all your data will be exported over from Amazon RDS MySQL to the AWS S3 bucket. You can end your tmux session by executing `Ctrl+B &`.

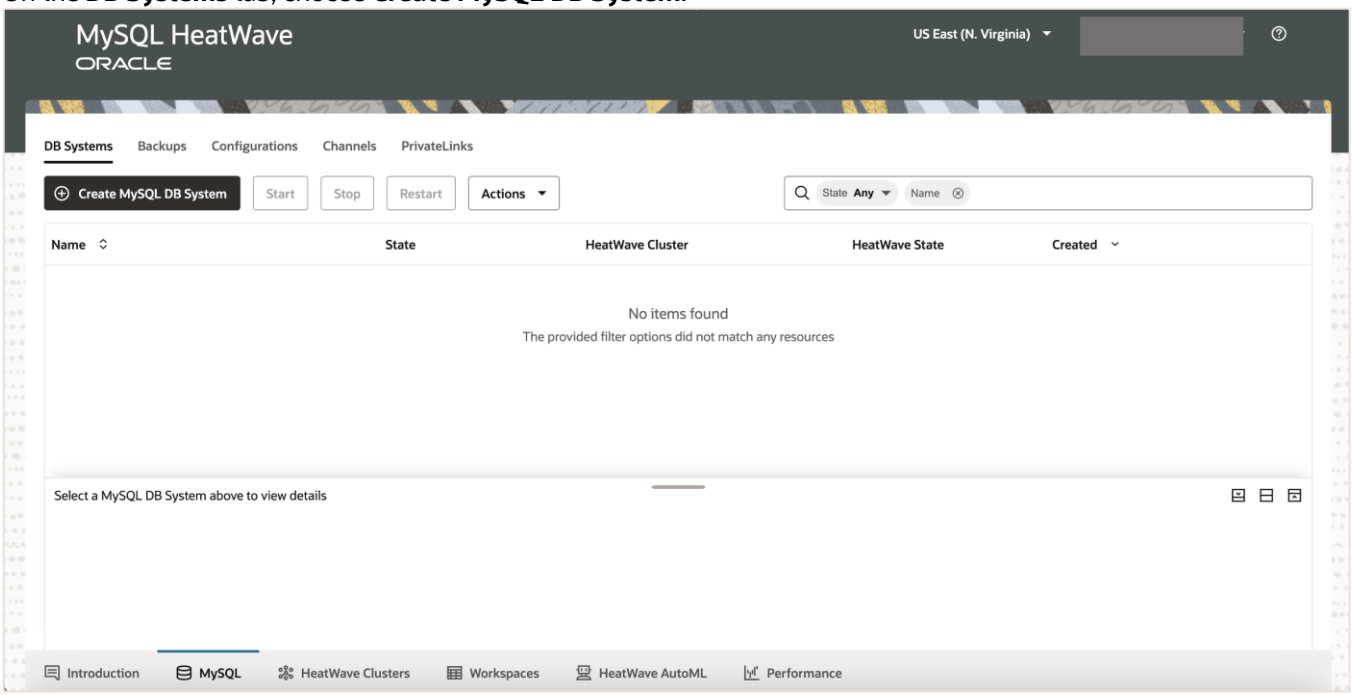
37. Open the AWS S3 Console and verify whether the dump was successful.

VI) Create a HeatWave MySQL on AWS DB System and a HeatWave Cluster.

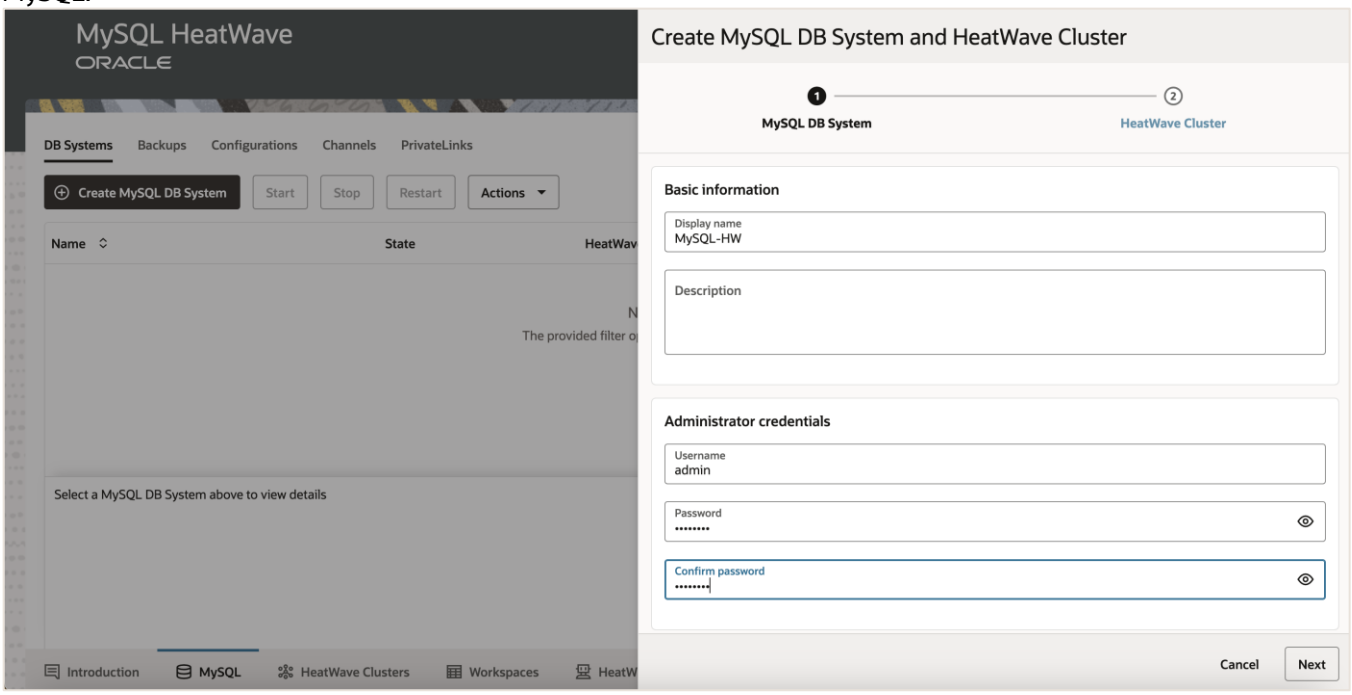
38. Log in to the HeatWave MySQL on AWS Console.
39. After logging in, click on the **MySQL** tab.



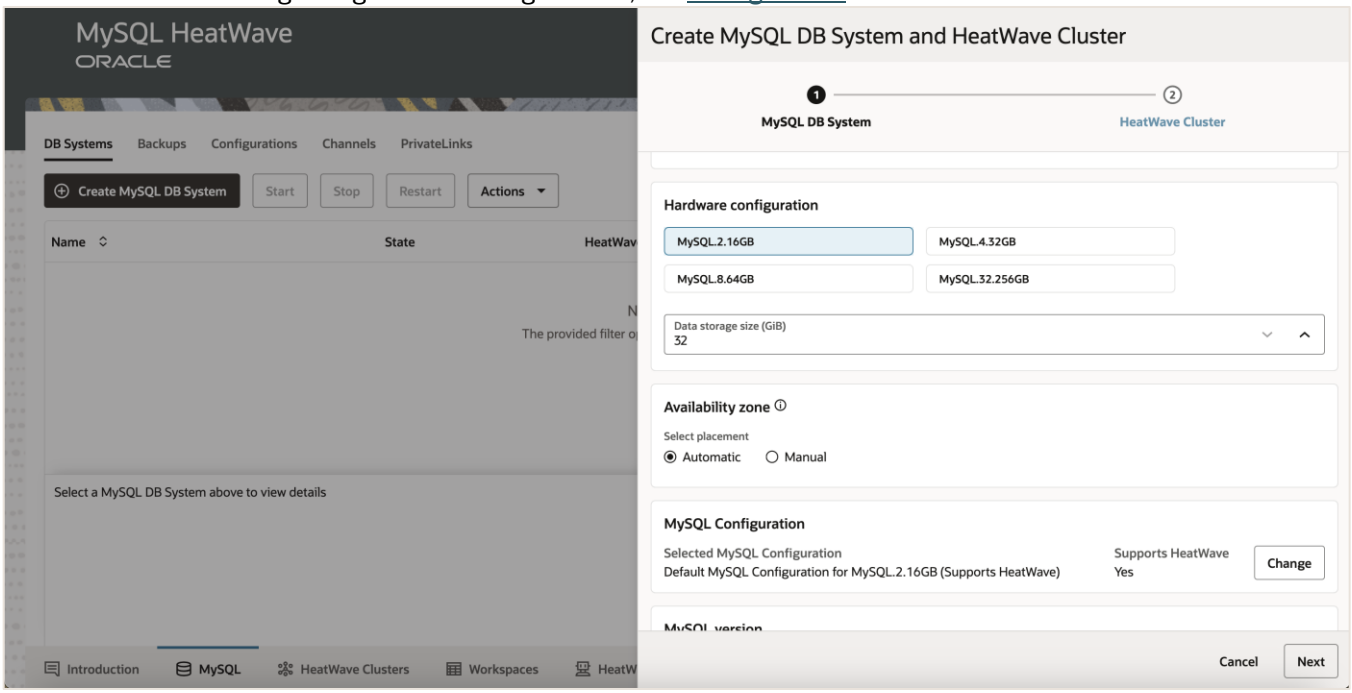
40. On the **DB Systems** tab, choose **Create MySQL DB System**.



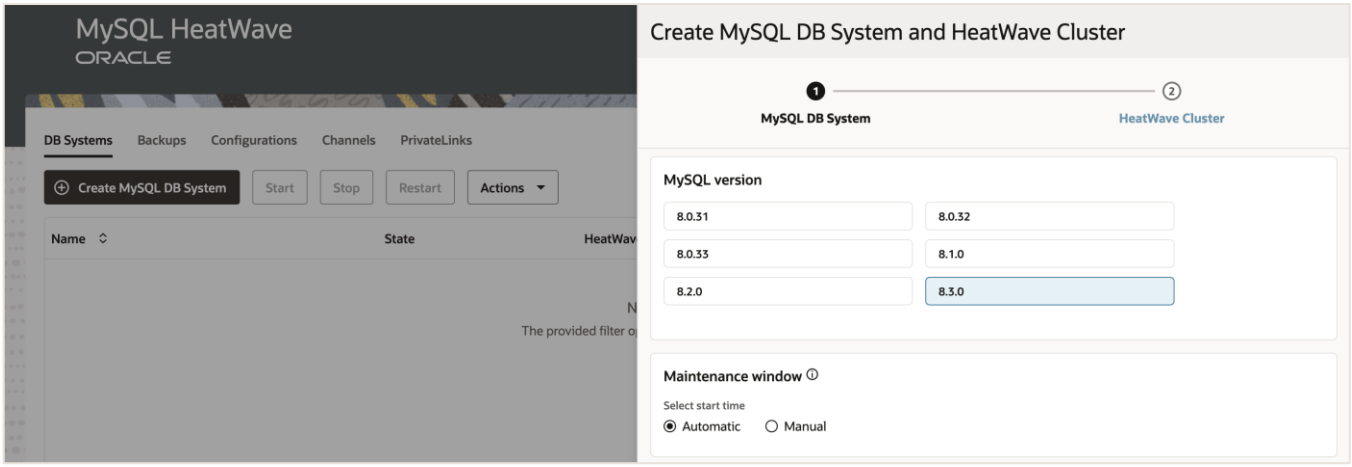
41. The **Create MySQL DB System and HeatWave Cluster** dialog will open. Enter a MySQL **Display Name** and a **Description** (optional). Configure your **Administrator credentials** that will be used to manage HeatWave MySQL.



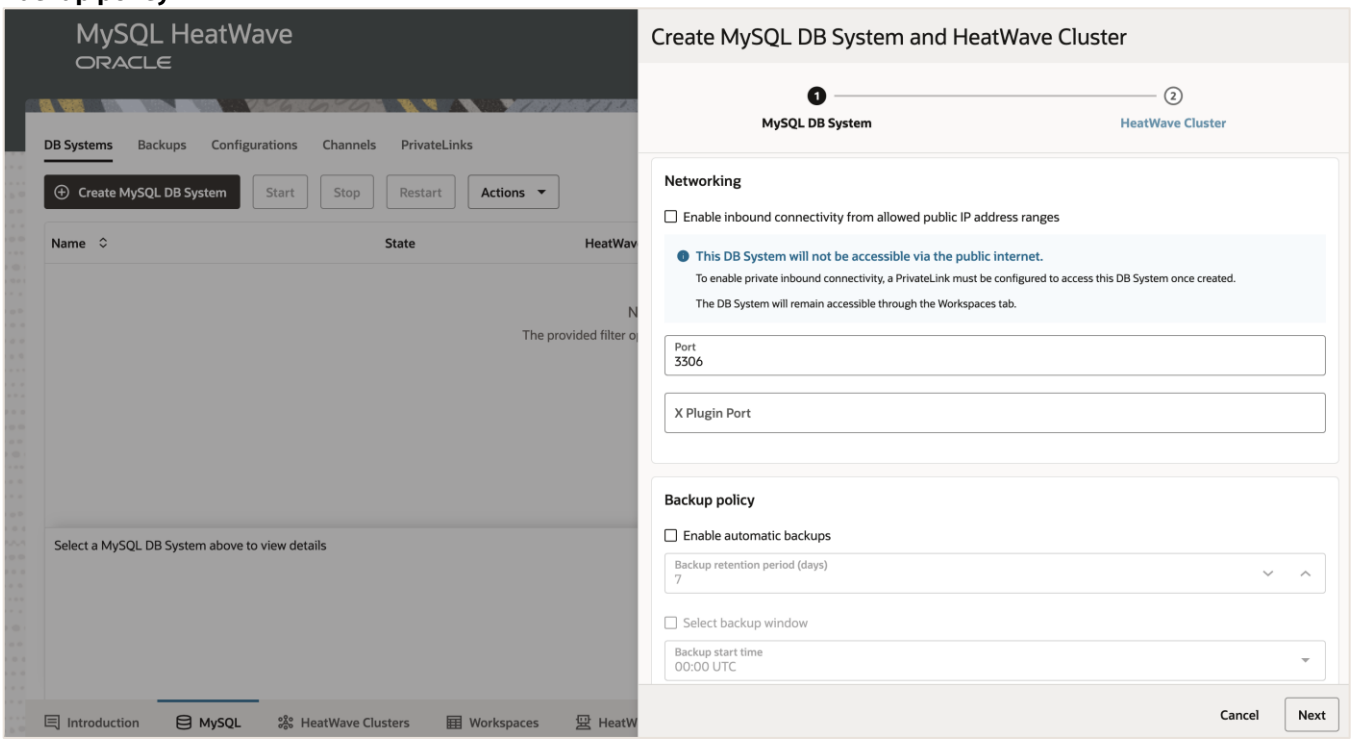
42. Next, select your **Hardware configuration** by choosing the appropriate amount of vCPUs and Memory and configure your **Data storage size**. Leave the **Availability zone** and **MySQL Configuration** as-is. If you have a custom MySQL configuration that you would like to apply to your MySQL – you can do so by clicking **Change**. For more information regarding custom configurations, see Configuration.



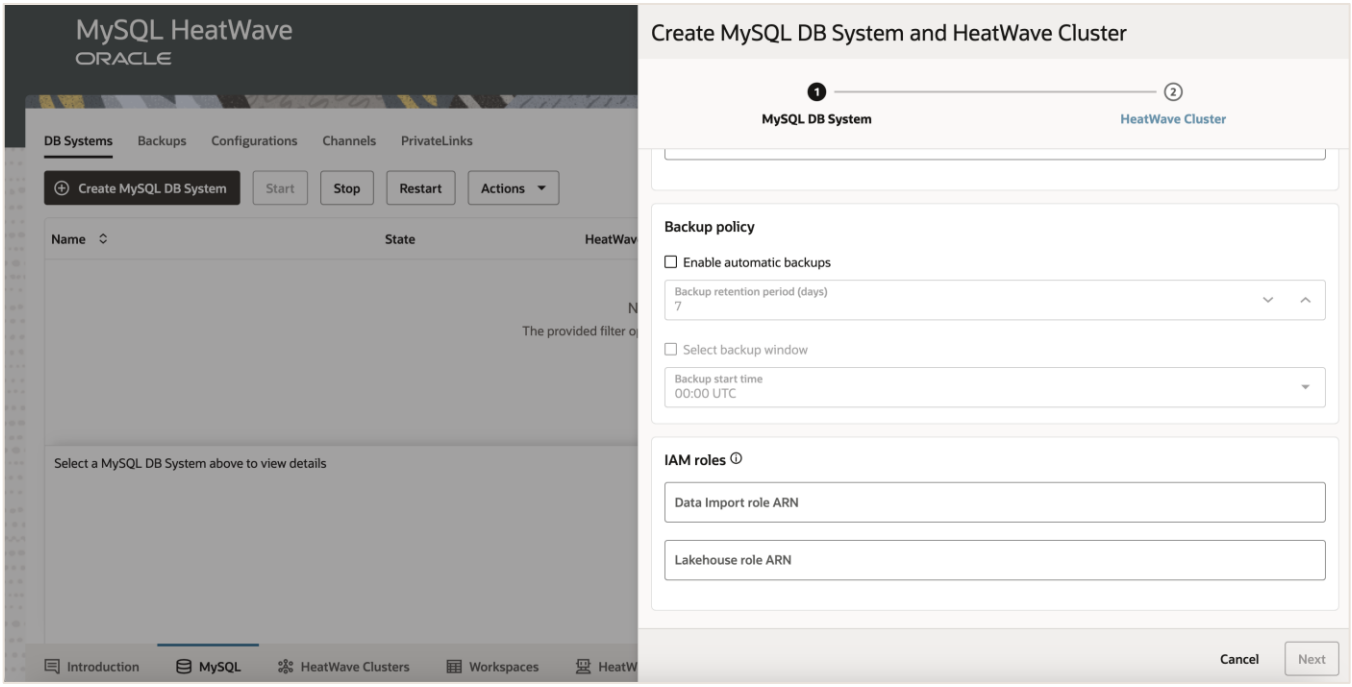
43. For **MySQL version**, choose the MySQL server version to deploy. You have two options, **Innovation** or **Bug fix**. With the new MySQL versioning model, you have the flexibility to select an innovation or a bug fix release. Both releases are production-grade quality. MySQL innovation releases allow you to access the latest features and improvements. Innovation releases are ideal for fast-paced development environments with high levels of automated tests and modern continuous integration techniques for faster upgrade cycles. MySQL bug fix releases (aka long-term support releases) allow you to reduce the risks associated with changes in the database software behavior, as these releases only contain necessary fixes (bugfix and security patches). For more information regarding MySQL innovation and bug fix releases, see Introducing MySQL Innovation and Bug fix versions. For this guide, we have chosen **8.3.0**. Select the start time for the **Maintenance Window**.



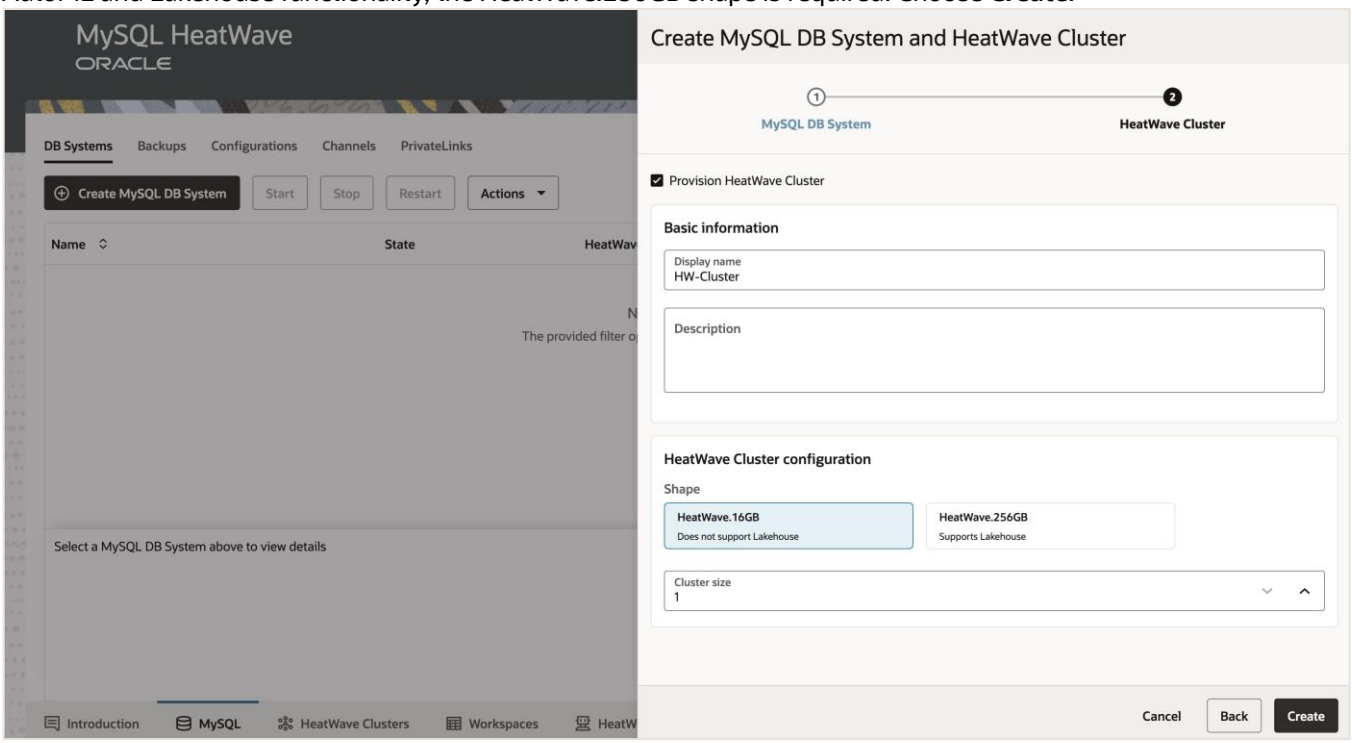
44. For **Networking**, check the **Enable inbound connectivity from allowed public IP address ranges** if you would like your MySQL DB System to be accessible via the public internet and specify the **Allowed public IP address ranges**. For this guide, we have chosen not to do that. Configure your **Port**, **X Plugin Port**, and the **Backup policy**.



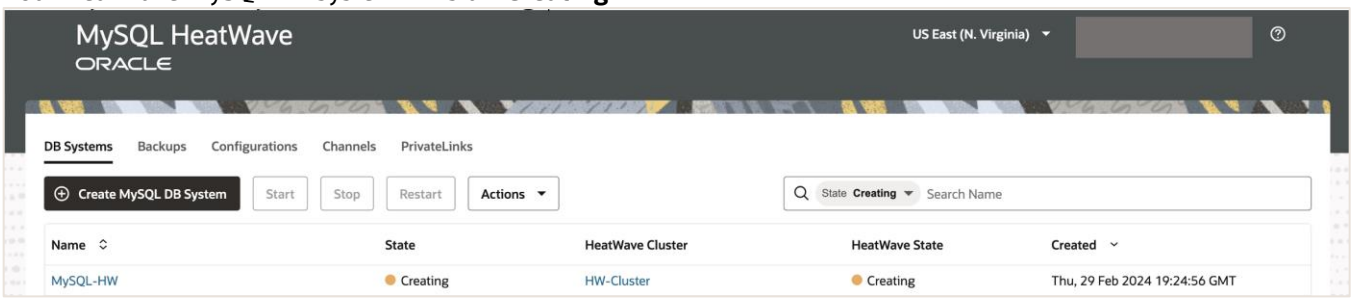
45. For **IAM roles**, leave it as-is. Select **Next**.



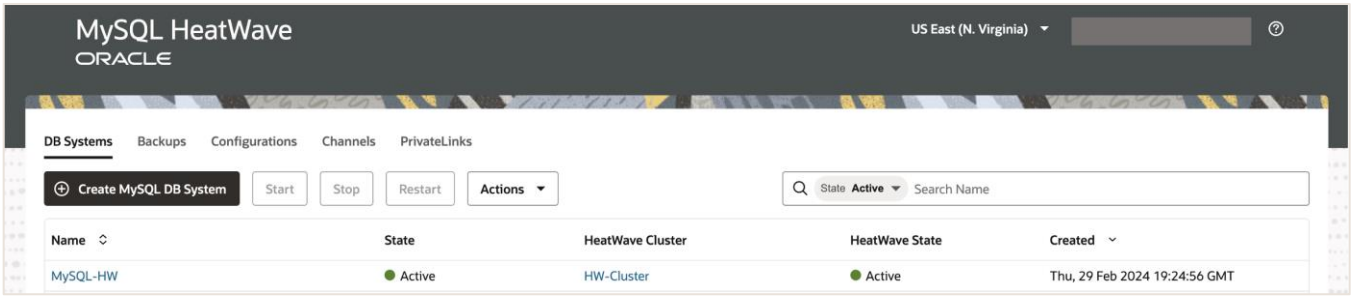
46. Select whether to **provision a HeatWave Cluster**, which will allow you to run OLAP (analytics queries) and ML (machine learning) workloads alongside OLTP. Give your Cluster a **Display name** and **Description** (optional). Lastly, configure the **shape** and **Cluster size**. The HeatWave.16GB shape can process up to 25 GB of data and the HeatWave.256GB shape can process up to 400 GB of data. If you intend to use HeatWave AutoML and Lakehouse functionality, the HeatWave.256GB shape is required. Choose **Create**.



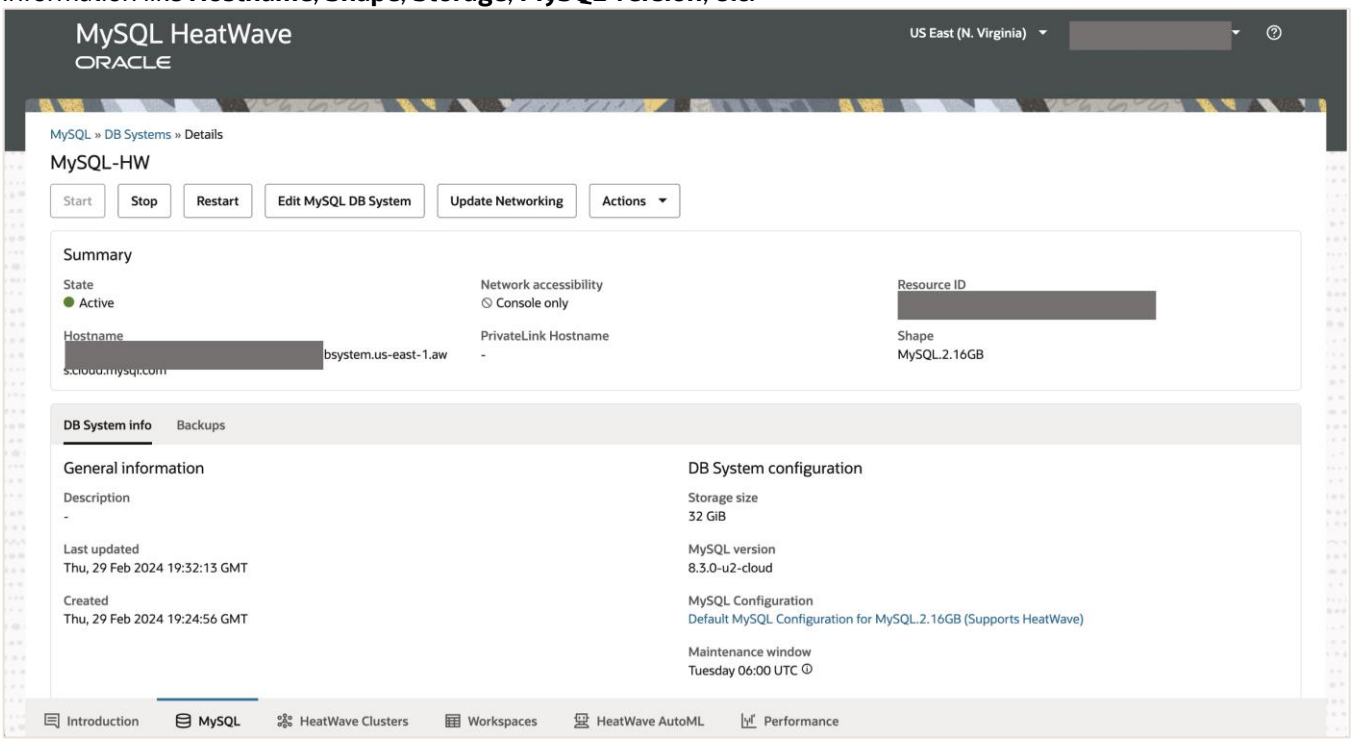
47. Your HeatWave MySQL DB system will start **Creating**.



48. After approximately 15-20 minutes, the HeatWave MySQL DB system will change its state from Creating to **Active**.

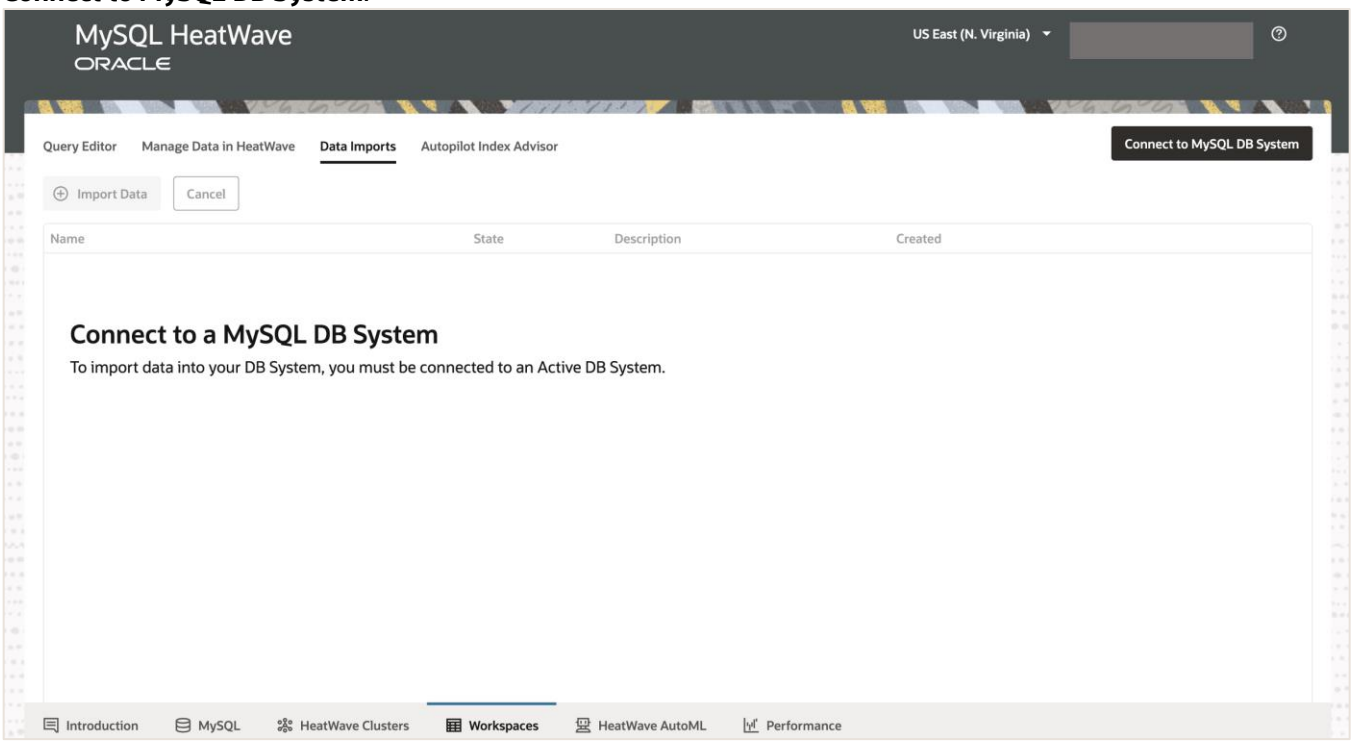


49. Click on the name of your MySQL DB System to open the **MySQL DB System Details** page. Here you can see information like **Hostname**, **Shape**, **Storage**, **MySQL version**, etc.

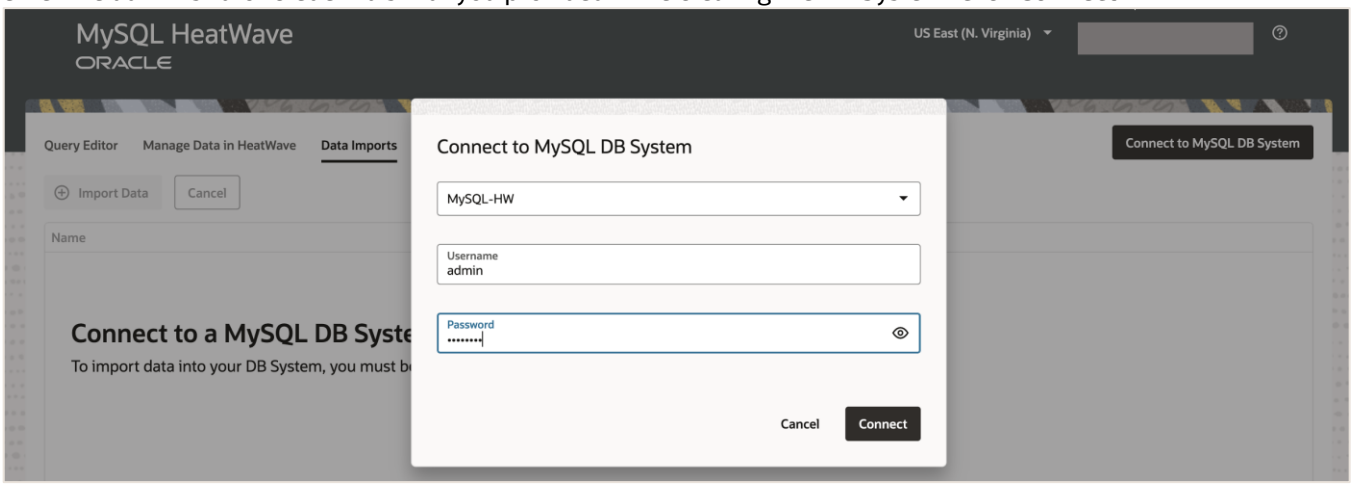


VII) Import data from AWS S3 bucket to HeatWave MySQL on AWS.

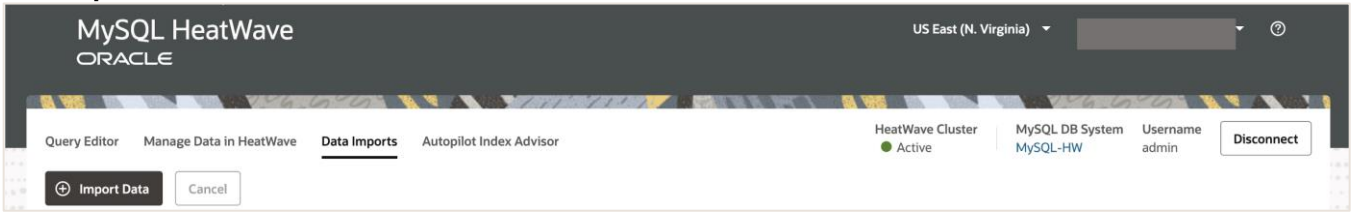
50. It is now time to import the Amazon RDS MySQL data sitting in the S3 bucket to HeatWave MySQL on AWS using the Data Import feature.
51. In the HeatWave MySQL Console, click the **Workspaces** tab, and then click the **Data Imports** tab. Click **Connect to MySQL DB System**.



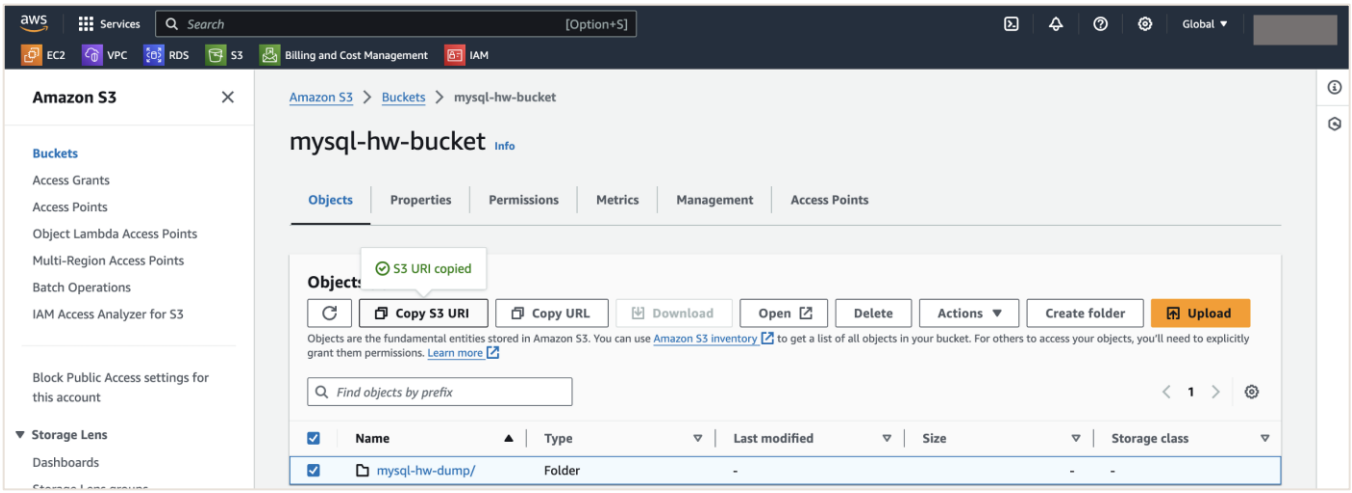
52. In the **Connect to MySQL DB System** dialog, select the DB System to which you want to import data and enter the administrator credentials that you provided while creating the DB System. Click **Connect**.

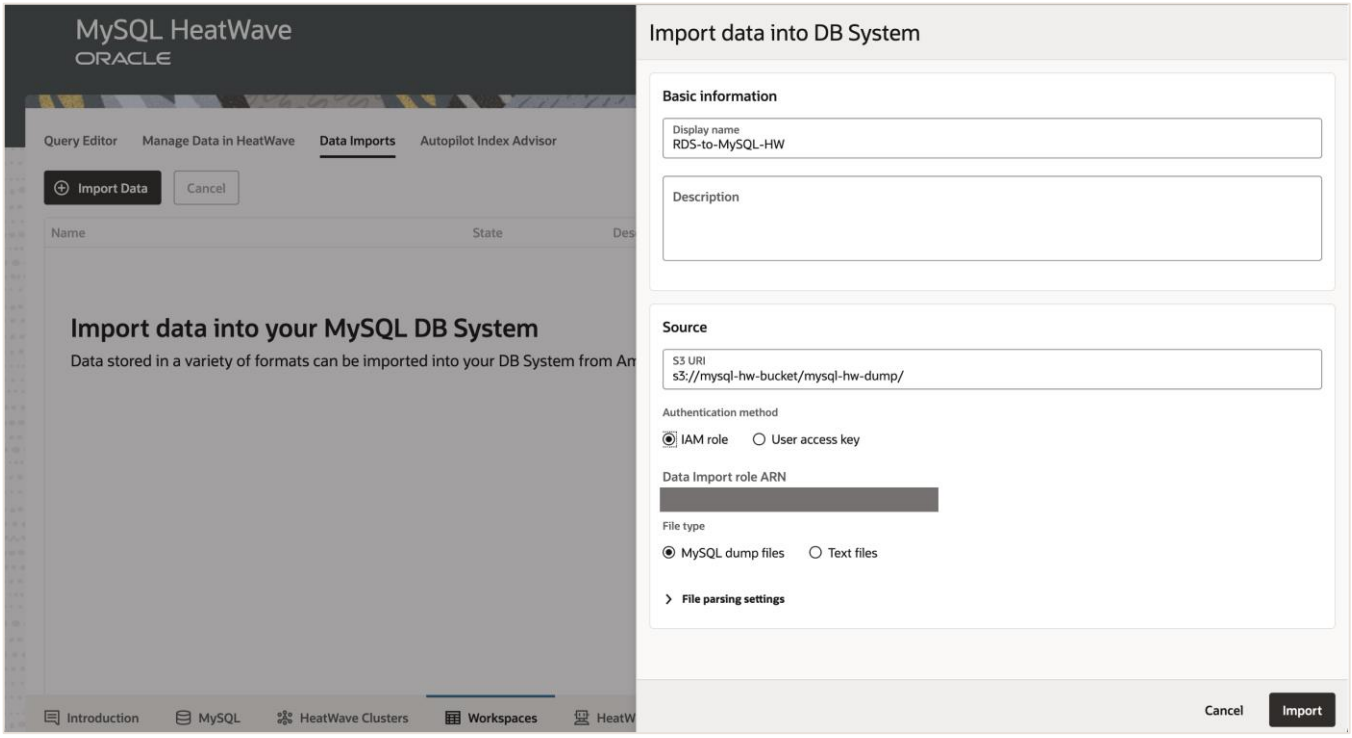


53. Click **Import Data**.

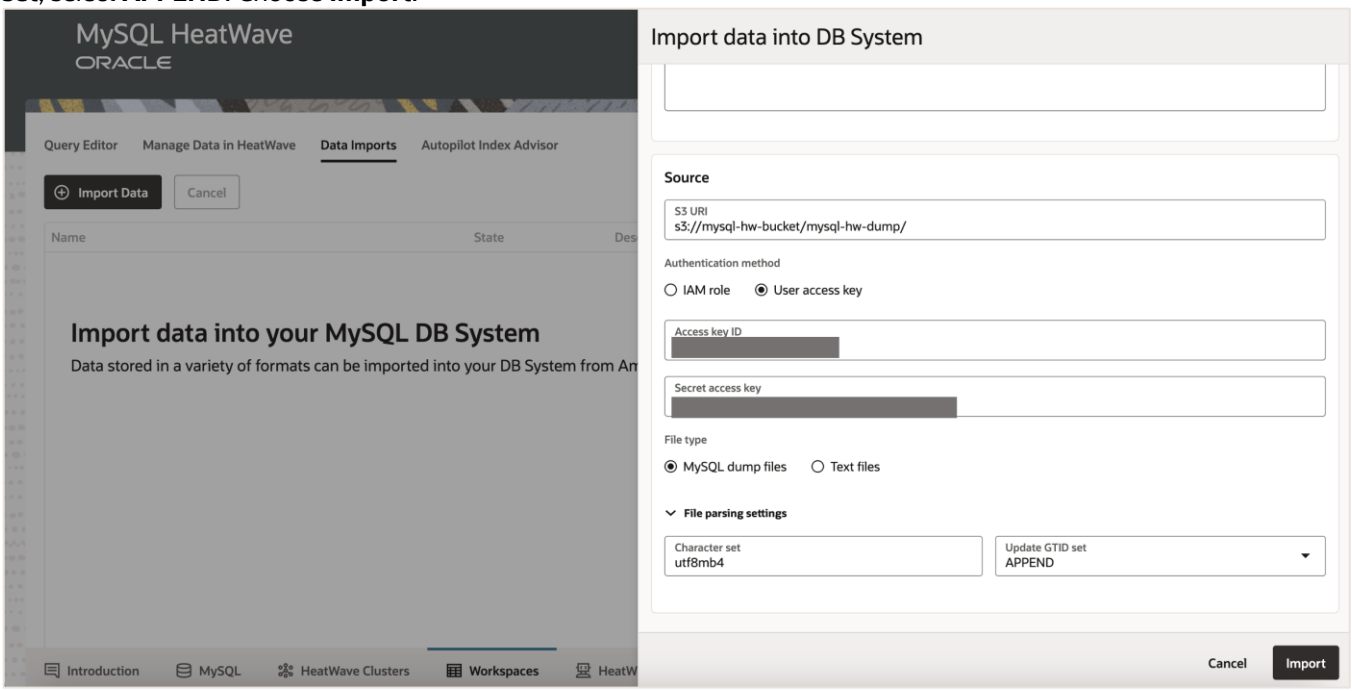


54. In the **Import data into DB System** dialog, enter a **Display name** and **Description** (optional) for the data import operation. Under **Source**, specify the **S3 URI** for the Object where your Amazon RDS MySQL dump is located. See below:

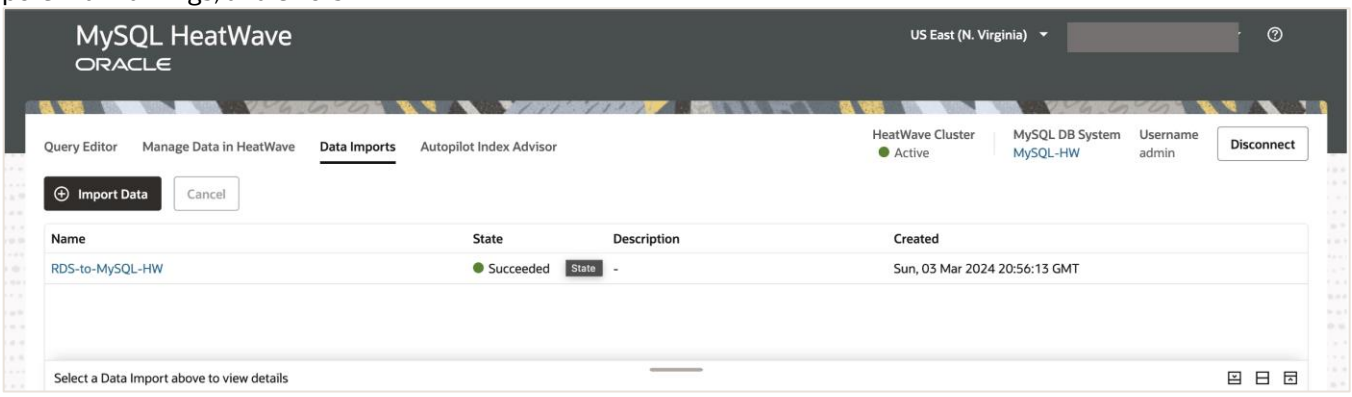




55. After specifying the S3 URI, choose **User access key** for the **Authentication method**. The recommended authentication method approach here is to use the IAM role, but for this guide, we will use the user access key that we created in step 6. For more information on how to use the IAM role, see Data Import Feature. The user using the access key must have the AmazonS3FullAccess permissions policy. Under **File Type**, specify **MySQL dump files**, for **Character set**, enter the **character set of your dumped data**, and for **Update GTID set**, select **APPEND**. Choose **Import**.

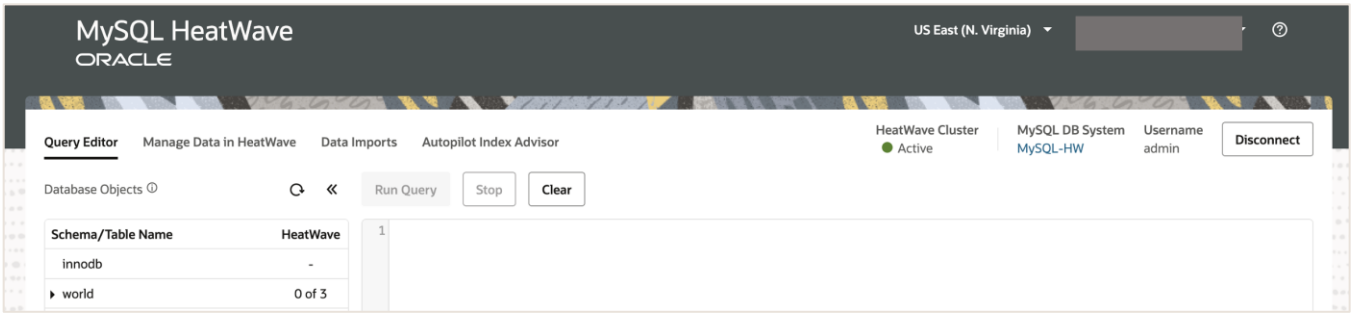


56. Your data will now start importing from the S3 bucket to HeatWave MySQL on AWS and the status of the Data Import changes to **In Progress**. Once the operation is complete, the status will change to **Succeeded**. Click or select a Data Import operation to view more information like the import progress of the tables, potential warnings, and errors.



VIII) (Optional) Use the Query Editor tab to verify whether the data was migrated successfully from Amazon RDS MySQL to HeatWave MySQL on AWS.

57. On the Workspaces page, click **Query Editor** and ensure you are connected to your HeatWave MySQL on AWS DB System. Once you are connected, you can see all your schemas and tables on the left panel, like below:



58. You can run the below query on every table that you have for your Amazon RDS MySQL and HeatWave MySQL on AWS to ensure that the row count matches on both sides:

```
MySQL SQL> SELECT COUNT(*) FROM <schema-name>.<table-name>;
```

59. Here is our row count comparison for Amazon RDS MySQL and HeatWave MySQL on AWS:

Amazon RDS MySQL row count:

```
MySQL database-1.[redacted].us-east-2.rds.amazonaws SQL > USE world;
Default schema set to `world`.
Fetching global names, object names from `world` for auto-completion... Press ^C to stop.
MySQL database-1.[redacted].us-east-2.rds world SQL > SELECT COUNT(*) FROM city;
+----------+
| COUNT(*) |
+----------+
|     4079 |
+----------+
1 row in set (0.0084 sec)
MySQL database-1.[redacted].us-east-2.rds.amazonaws world SQL > SELECT COUNT(*) FROM coun
try;
+----------+
| COUNT(*) |
+----------+
|      239 |
+----------+
1 row in set (0.0009 sec)
MySQL database-1.[redacted].us-east-2.rds.amazonaws world SQL > SELECT COUNT(*) FROM coun
trylanguage;
+----------+
| COUNT(*) |
+----------+
|      984 |
+----------+
1 row in set (0.0009 sec)
MySQL database-1.[redacted].us-east-2.rds.amazonaws world SQL >
```

HeatWave MySQL on AWS row count:

```
1 USE world;
2 SELECT COUNT(*) FROM city;
```

Query Results

Query completed on Mon, 04 Mar 2024 14:23:37 GMT (took 0.0020 seconds). Result set is limited to 1000 rows.

Results JSON Job Information

COUNT(*)
4079

```
1 USE world;
2 SELECT COUNT(*) FROM country;
```

Query Results

Query completed on Mon, 04 Mar 2024 14:23:08 GMT (took 0.0013 seconds). Result set is limited to 1000 rows.

Results JSON Job Information

COUNT(*)
239

```
1 USE world;
2 SELECT COUNT(*) FROM countrylanguage;
```

Query Results

Query completed on Mon, 04 Mar 2024 14:24:09 GMT (took 0.0015 seconds). Result set is limited to 1000 rows.

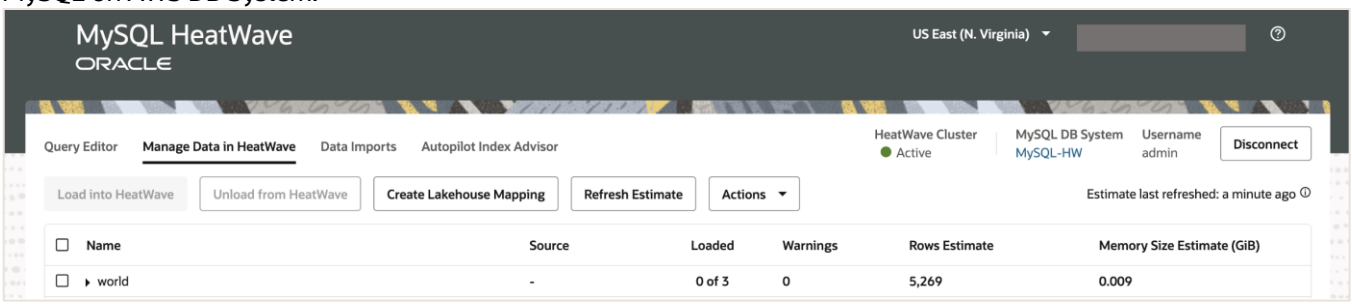
Results JSON Job Information

COUNT(*)
984

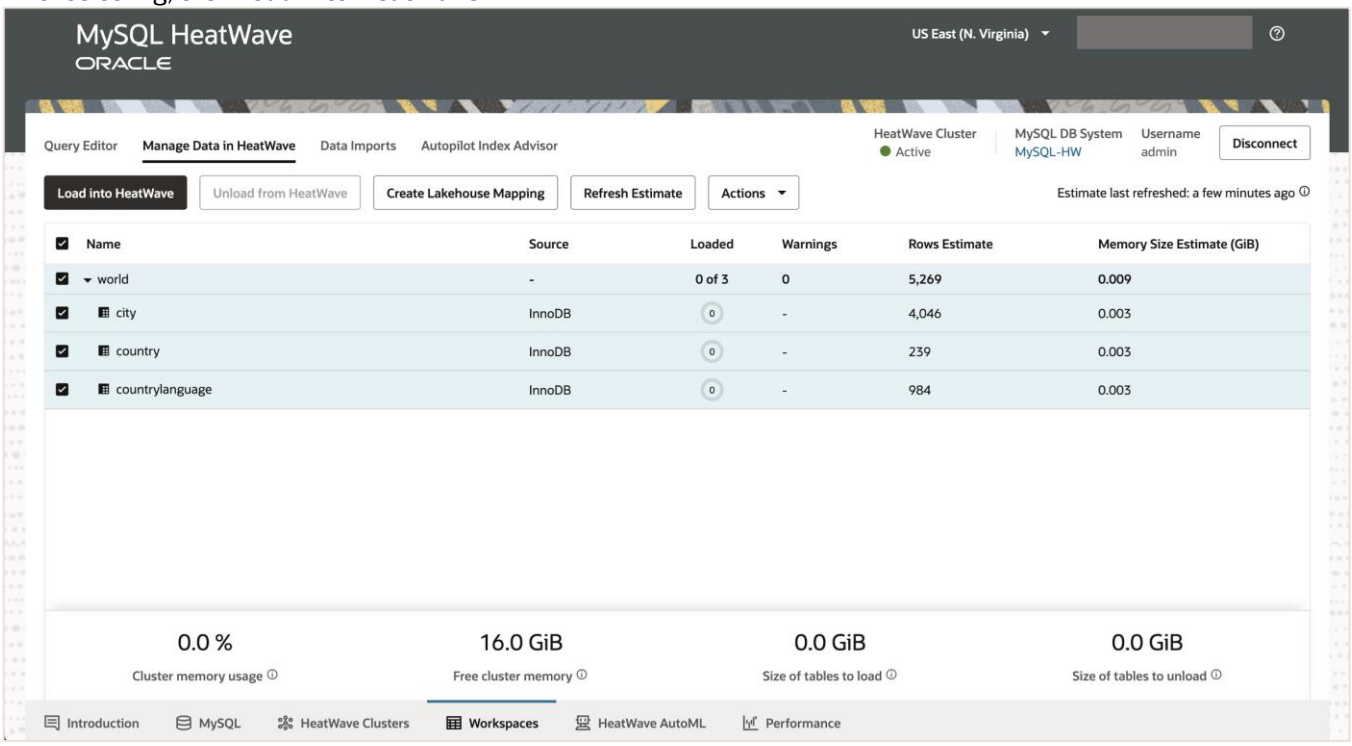
60. After validating, you can have your application(s) point to the new HeatWave MySQL on AWS DB System.

IX) If the HeatWave option was enabled during HeatWave MySQL on AWS DB System creation, load data from MySQL InnoDB storage into the HeatWave Cluster using automation.

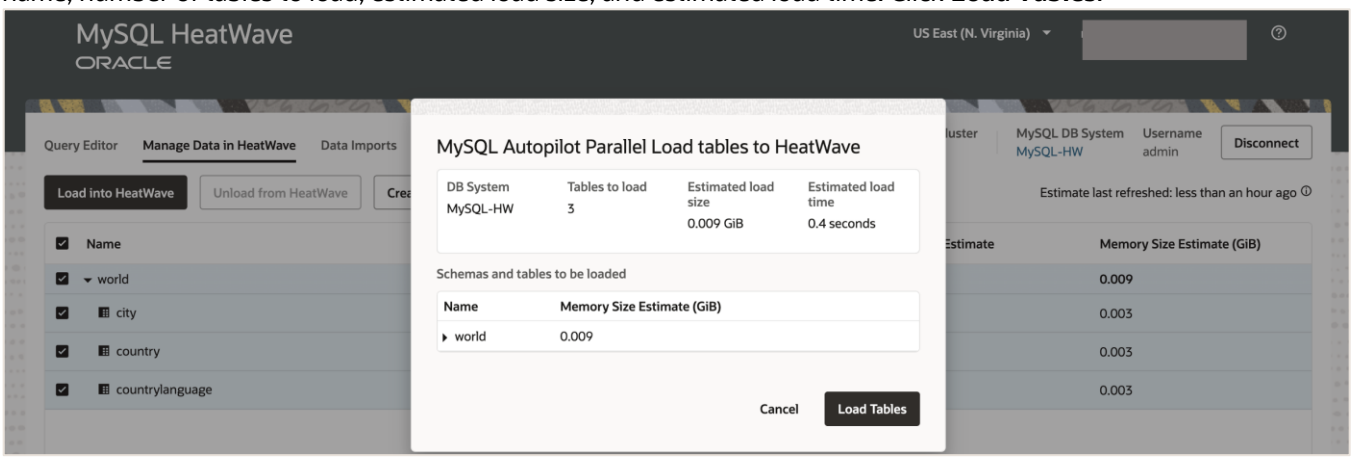
61. On the Workspaces page, click **Manage Data in HeatWave** and ensure you are connected to your HeatWave MySQL on AWS DB System.



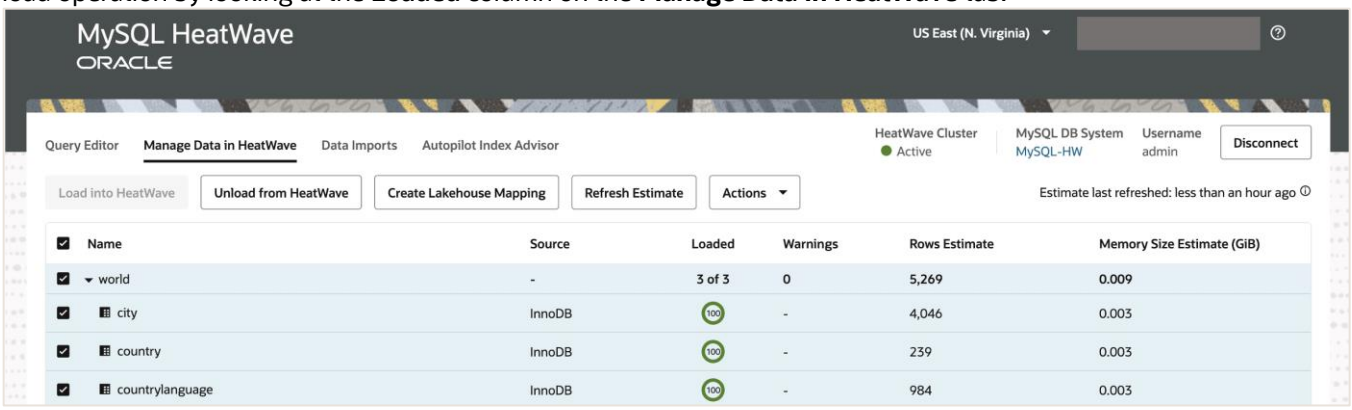
62. Click the **check box present in front of the schema or table name** to select the schemas and tables you want to load into HeatWave for query acceleration and to run OLAP and ML workloads - alongside OLTP. After selecting, click **Load into HeatWave**.



63. A dialog will appear which will provide a summary of the load operation. It shows information like DB System name, number of tables to load, estimated load size, and estimated load time. Click **Load Tables**.



64. Your data will begin loading into HeatWave from the MySQL InnoDB storage. You can verify the status of the load operation by looking at the **Loaded** column on the **Manage Data in HeatWave** tab.



65. You now have a complete HeatWave MySQL cluster.

To learn more about using HeatWave MySQL on AWS, please visit our documentation.

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